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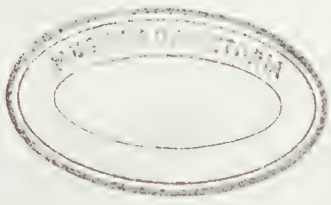

RECORDS OF THE SOUTH AUSTRALIAN MUSEUM

VOLUME 18 NUMBER 1 January, 1980

A REVISION OF THE SYSTEMATICS OF AUSTRALIAN SIPUNCULANS (SIPUNCULA)

By S. J. EDMONDS

SOUTH AUSTRALIAN MUSEUM
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NATIONAL MUSEUM
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A REVISION OF THE SYSTEMATICS OF AUSTRALIAN SIPUNCULANS (SIPUNCULA)

by

S. J. EDMONDS
Honorary Associate, South Australian Museum, Adelaide, South Australia, 5000

ABSTRACT

EDMONDS, S. J. 1979. A revision of the systematics of Australian sipunculans (Sipuncula). *Rec. S. Aust. Mus.* 18(1): 1-74.

The author lists 57 species and subspecies of sipunculans reported from Australia and has examined Australian specimens of 43 of them. Three new species are described—*Phascolion cronullae* from the shell of *Gazameda gunnii* (Reeves), *Themiste variospinosa* and *Paraspidosiphon johnstoni*. The other species examined are redescribed. The Australian sipunculans belong to 4 families and 12 genera. The genus *Themiste* is considered to comprise 3 new subgenera: *Themiste* s.s., *Lagenopsis* and *Stephensonum*. The genus *Centrosiphon* Shipley, 1903, because the type is thought to be a *Golfingia*, is considered to be invalid. Specimens identified by Edmonds (1956) as *Aspidosiphon klunzingeri* Selenka & de Man are now considered to be a new species, *Paraspidosiphon johnstoni*. Specimens identified by Edmonds (1956) as *Aspidosiphon steenstrupii* Diesing are now thought to be *Paraspidosiphon formosanus* (Sato, 1939). *Phascolosoma heronis* Edmonds, 1956 is now considered to be a junior synonym of *Phascolosoma stephensoni* (Stephen, 1942) and *Phascolosoma dunwichi* Edmonds, 1956 a junior synonym of *Phascolosoma scolops* (Selenka & de Man, 1883). *Aspidosiphon elegans elegans* (Chamisso & Eysenhardt, 1821) is considered to include *Aspidosiphon exilis* Sluiter, 1902. Suggestions about narcotising and dissecting specimens are given and the ecology and habits of the group are discussed. Maps showing the distribution of sipunculans in Australia are also included.

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I. INTRODUCTION

Aim of the study

It is twenty years since the last general work on the systematics of the Australian sipunculans was published (Edmonds 1955, 1956). In the meantime more specimens have been collected and changes have been made in the systematics of the phylum. Some of the more recently collected specimens are new species and others are species not previously reported from Australia. Further, the additional specimens enable information about some of the previously described species to be extended and imperfections in their descriptions, and even errors in their identification, to be corrected. The aim of the study is to bring up to date, as far as it is possible, the systematics of the Australian sipunculans. Seeing that many parts of the coast, especially the northern ones, have still not been visited by collectors it seems almost certain that more species will be found in the future.

In identifying the animals I have relied mostly on the description of their external and internal anatomy. Little or no attempt has been made to use some of the more modern methods that are sometimes employed to separate closely related species and to determine new ones, for instance the

use of electrophoretic techniques (Manwell 1977 p. 331) or the study of chromosones. The difficulties of using some of these methods when most of one's material is already fixed are great. As far as is possible I have worked with the concept in mind that a species consists of a population of animals and that it is not just a single animal or type specimen.

Most of the specimens have been collected intertidally or from the upper sublittoral zone and only a few have been dredged. I have included specimens from Lord Howe Island but not from Norfolk Island nor the eastern regions of the Tasman Sea, although it is possible that the range of the species may extend to the home waters of Australia. I have included the records of Australian species not seen by me but which have been identified by other workers. I have made little or no attempt to examine these records critically but I have included the species in the keys that are given in the paper.

Characters of the phylum Sipuncula†

Sipunculans are a group of unsegmented, coelomate, bilaterally symmetrical, marine invertebrates. Their body consists of two chief parts, a cylindrical, globular, flask- or sac-like, highly muscular trunk and a highly extensible and comparatively slender introvert, that is capable of complete retraction within the trunk. The mouth opens at the anterior extremity of the introvert and is usually wholly or partly surrounded by a group of tentacles or a tentacular fold. The introvert may be armed with hooks or spines (sometimes both); it may, however, be unarmed. Small glandular openings and hemispherical, conical or rather flat papillae are usually present on the trunk and introvert. Setae are absent. The alimentary canal is long and usually wound into a spiral for most of its length. The anus is usually situated dorsally on the anterior surface of the trunk. In most genera two nephridia open to the exterior on each side of the nerve cord near the anus but only one nephridium is found in the genera *Onchnesoma* and *Phascolion*. A contractile vessel is attached to the anterior region of the oesophagus. Anteriorly it branches into the tentacles but posteriorly it ends blindly. It is usually single but sometimes double; it may be simple or give off few to many tubules which may be long or short. The blood cells contain the respiratory pigment haemerythrin. The ventral nerve cord is unsegmented and the brain lies dorsally near the anterior extremity of the introvert. The gonads develop at the base of the retractors and the sexes, although separate, are indistinguishable externally. Fertilisation is external, cleavage of the zygote is spiral and the larva is a trochophore. No segmentation appears during development. One species is known to be a protandrous hermaphrodite and two species are known to reproduce asexually.

Footnote†. Based on the characters given in Stephen & Edmonds (1972); pp.18-19.

Sipunculans, echiurans, holothurians etc.

Holothurians, sand-burrowing anemones, nemertines and especially echiurans are often mistaken for sipunculans. It is not difficult, however, to distinguish between them. The introvert of a sipunculan can be completely retracted into the body cavity but the proboscis of an echiuran cannot. The mouth of a sipunculan is placed at the anterior tip of the introvert but in an echiuran it lies on the trunk at the base of the proboscis. The anus of a sipunculan is usually situated anteriorly on the dorsal surface of the trunk but in an echiuran it is at the posterior extremity of the trunk. Tentacles are usually associated with the mouth of a sipunculan but are lacking in an echiuran. Setae are absent in sipunculans but usually a pair of them protrudes from the surface of an echiuran just posterior to the mouth.

Although they possess tentacles, anemones lack an introvert, a tubular alimentary canal and nephridia. Nemertines possess a posteriorly placed anus, they lack a body cavity and are usually without tentacles. Holothurians lack an introvert and the anus is posterior.

Where sipunculans are found

Sipunculans live in tropical, temperate and polar seas and their bathymetric range is wide. Many have been found intertidally and others have been dredged at depths of 6 860 m (Murina, 1964a p. 250; Stephen & Edmonds, 1972 p. 4 and 79; Cutler, 1977 p. 155). Fisher (1952 p. 371) thinks that, being soft bodied and defenceless creatures, they will probably live in any protected place that provides access to reasonably clear water and food.

In Australia most sipunculans have been collected intertidally or from shallow waters. They have been found in limestone reefs, in reef-forming and solitary corals, in mangrove flats, under stones, in fissures of non-calcareous rocks, in clumps of mussels, in masses of serpulid worms, in cracks in wooden jetty piles, in the holdfasts of algae, amongst the roots of marine angiosperms, in firm sand, in fine mud, in the empty shells of a number of molluscs and in the tubes and tests of larger foraminiferans.

Records of some species dredged off the Australian coast are given in Murina (1972) and Cutler (1977).

The ecological importance of sipunculans

Sipunculans perform a number of roles in the environment. Most are detritus feeders, some assist in the breaking down of limestone and

coral reefs, some serve as food for other animals, some live commensally with solitary corals, anemones and molluscs, and others act as either the intermediate or final hosts of parasites.

The gut of sipunculans usually contains sand, mud, small particles of coral or limestone rock, pieces of algae or marine angiosperms, fragments of molluscan shells and echinoderm exoskeleton, the frustules of diatoms and the skeletal parts of foraminiferans. The information suggests that sipunculans are detritus feeders and that they extract any food contained in whatever they ingest. Chin and Wu (1950) claimed that diatoms were an important constituent of the food of a number of sipunculans collected at Amoy, China. In her experiments on the development of sipunculans Rice (1970: p. 142) fed the larvae on algal cultures of *Phaeodactylum tricornutum* and *Isochrysis galbana* and the larvae of *Phascolosoma agassizii* on "mixed diatoms and dinoflagellates collected from tidal pools" (Rice 1973 p. 3).

Very little experimental work, however, has been done on the feeding habits of the group. Peebles and Fox (1933) observed (1) that *Themiste* (= *Dendrostomum*) *zostericola* burrows in perfectly clean sand which contains no food but that in these conditions the animal does not ingest the sand, (2) that the tentacles are sensitive to small particles of food and to traces of chemicals and (3) that the anterior region of the introvert, the tentacles and the collar are the most senstitive to contact with foreign substances. It is possible, therefore, that sipunculans do not indiscriminately swallow their environment but that they are able to exercise some selection as to what they eat. Gardiner (1903: p. 333) claims that some sipunculans break down coral fragments into smaller particles. They do not, however, possess a crop and gizzard like earthworms or a gastric mill like some crustaceans.

Rice (1976 p. 126) reports that there are at least two patterns of feeding behaviour in rock-dwelling sipunculans. Species with long, extensible introverts and short digitiform tentacles feed by extending their introvert from the mouth of the burrow and grazing the surface of the rock near them. She says, "*Phascolosoma perlucens*, maintained in the laboratory in intact burrows has been observed to feed from the surface of the rock on sediment and detritus. Some particles adhere directly to the tentacles while others seem to be scraped off the rock by the small hooks of the introvert." On the other hand rock-dwelling species with long filiform tentacles and relatively short introverts such as *Phascolosoma antillarum* and *Themiste lageniformis* make use of a ciliary-mucus mechanism. "The tentacular crown is extended above the mouth of the burrow and particles adhering to the sticky tentacles are directed by ciliary currents into the digestive tract."

Although sipunculans may inhabit the tubes and cavities made by other animals, it is known that some species, especially those belonging to the genera *Phascolosoma, Aspidosiphon, Paraspidosiphon, Cloeosiphon, Lithacrosiphon* and *Themiste* are able to construct their own homes in calcareous rock. Such species play an important part in the breaking down of coral and limestone reefs. The importance of sipunculans as members of a coral reef community is discussed in Rice (1976: p. 122). How soft bodied creatures are able to bore into hard rock is a baffling problem. The researches of Rice (1969), Rice and McIntyre (1972) and Williams and Margolis (1974) suggest that mechanical abrasion and chemical action are involved.

Sipunculans are a source of food for a number of different animals. Kohn (1975 pp. 313-331) has reviewed the topic in an article on predation on sipunculans. Pallas (1774) reported that *Siphonosoma edule* was used as food by the Batavians and Sato (1935) that *Sipunculus indicus* was eaten by the natives of Palau Is. Chin (1947) reported that *Sipunculus nudus* was eaten at Amoy, China and went as far as to supply a recipe for its preparation as a dish. Many fish eat sipunculans; Kohn (1975) lists two orders of elasmobranchs and six orders (17 families) of teleosts. He says that "the fishes are all generalized predators on benthic invertebrates but sipunculans, mainly *Aspidosiphon,* are the major prey of the stingray *Dasyatis americanus* and the margate *Haeumulon album* in the Caribbean. In the trunkfish *Lactophyrs triqueter* and the economically important haddock, *Melanogrammus aeglefinnus,* in the Barents Sea, *Aspidosiphon spinoscutatus* and *Golfingia margaritacea* are only second to polychaetes in the diets in nature. In other fishes sipunculans represent subsidiary or incidental components of the diet." In South Australia small specimens of *Sipunculus robustus* are sometimes found in the stomach of the local King George (spotted) whiting *Sillaginodes punctatus.* Some sipunculans collected in such a way by W. Zeidler (3/1/76) are in the collection of the South Australian Museum (reg. no. E 1072).

Kohn says that only a few invertebrates are known to prey on sipunculans in nature. Kohn (1970, 1975) reports that the gastropod *Mitra litterata* preys on sipunculans that burrow in the intertidal limestone reef at Oahu, Hawaii. Sixteen of the 24 specimens of *Mitra* that he examined were each found to contain the remains of one sipunculan. The species eaten were *Phascolosoma scolops, P. stephensoni (=P. heronis)* and *Aspidosiphon elegans.* It is believed that the animals were eaten mostly during the night.

The sipunculan *Aspidosiphon jukesii* Baird lives commensally in the base of the solitary corals, *Heteropsammia* and *Heterocyathus;* the association is well documented and described (Bouvier 1895; Sluiter 1902; Stephen and Robertson 1952; Goreau and Yonge 1968; Yonge 1975; Rice 1976). Some of Rice's observations are referred to in the present paper on p. 49. Specimens of *Golfingia hespera* (Chamberlin) were found as commensals in the tubes of *Cerianthus* (Fisher 1952) and syllids are sometimes found in association with specimens of *Phascolin* (see p. 30). A list of some molluscs associated with sipunculans is given in Stephen & Edmonds, 1972 p. 342.

Sipunculans may contain parasites in their gut, body fluids or tissues. The most commonly found parasitic protozoans are sporozoans, especially gregarines. Some of the records are listed in Stephen & Edmonds (1972 p. 341) and further information is given in Jones (1975b p. 349). Rhabdocoeles have been reported from the gut of at least four different sipunculans and encysted metacercaria of unidentified trematodes from the intestine, brain, tentacles, gonads and contractile vessel of several species (Stephen & Edmonds 1972 p. 341). Nematodes have been reported from the body cavity of at least three species (Augener, 1903 p. 361; Edmonds, 1976 p. 222; Jones, 1975a p. 343).

Narcotisation and dissection of sipunculans

Sipunculans are usually much more easily indentified if they have been relaxed before they are preserved. The nature and arrangement of the tentacles and the presence of hooks and spines are readily observed if the specimen has been narcotised. One way of doing this is to place them in a dish containing sea water to which is carefully added (drop by drop) some 80% alcohol in which some menthol has been previously dissolved. It may take from a half to six hours before the animals do not respond to touch. The specimens should then be left overnight in 5% neutral formalin and stored in 70% alcohol.

Not many sipunculans can be identified from their external appearance; most require to be dissected. One method is to pin them out under water in a dish containing a layer of solidified paraffin wax about 20 mm thick. Place the dorsal (anal) side uppermost. With the aid of a sharp scalpel or fine scissors and forceps cut the body wall longitudinally along a line just to one side of the anus. Lift up the body wall ahead of the cut so that the incision does as little damage as possible to the structures underneath. Cut the whole length of the trunk and pin back the flaps. Wash away coagulated blood with the aid of a stream of water from a wash bottle.

In order to make a mount of the introvert hooks or body papillae, snip off a small section of the skin and place it on a slide with a drop of glycerine. Tease up the tissue containing the hooks with the aid of two fine needles. When the preparation is now examined under low power single hooks or groups of hooks can often be seen. Remove unwanted tissue and cover with a cover slip. Only hooks that lie flat should be drawn. There is no need to tease the piece of tissue containing the papillae.

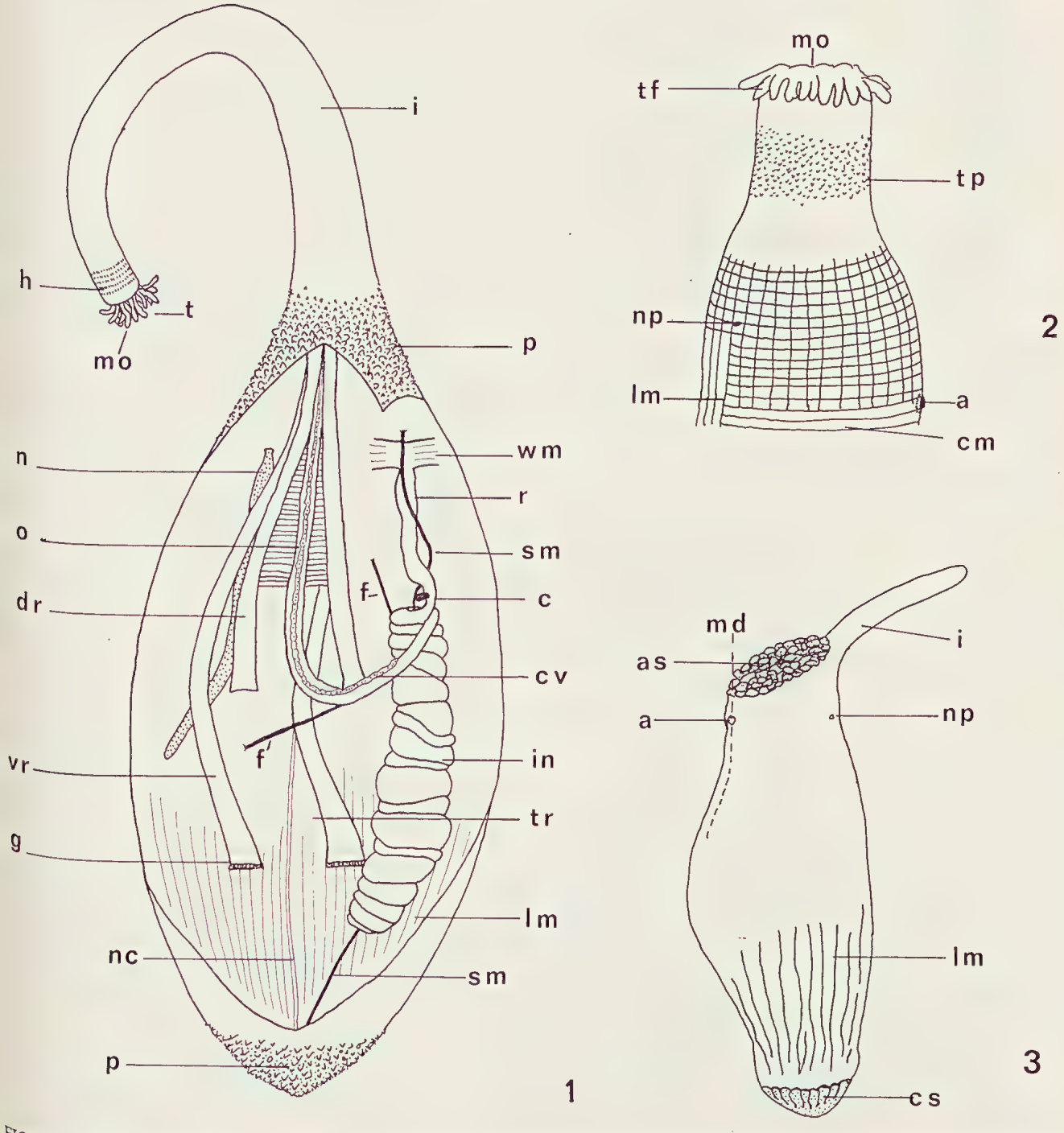
Figures 1-3 show some structures of a dissected sipunculan.

A glossary of terms used in sipunculan taxonomy is given in Stephen and Edmonds (1972 pp. 8-11).

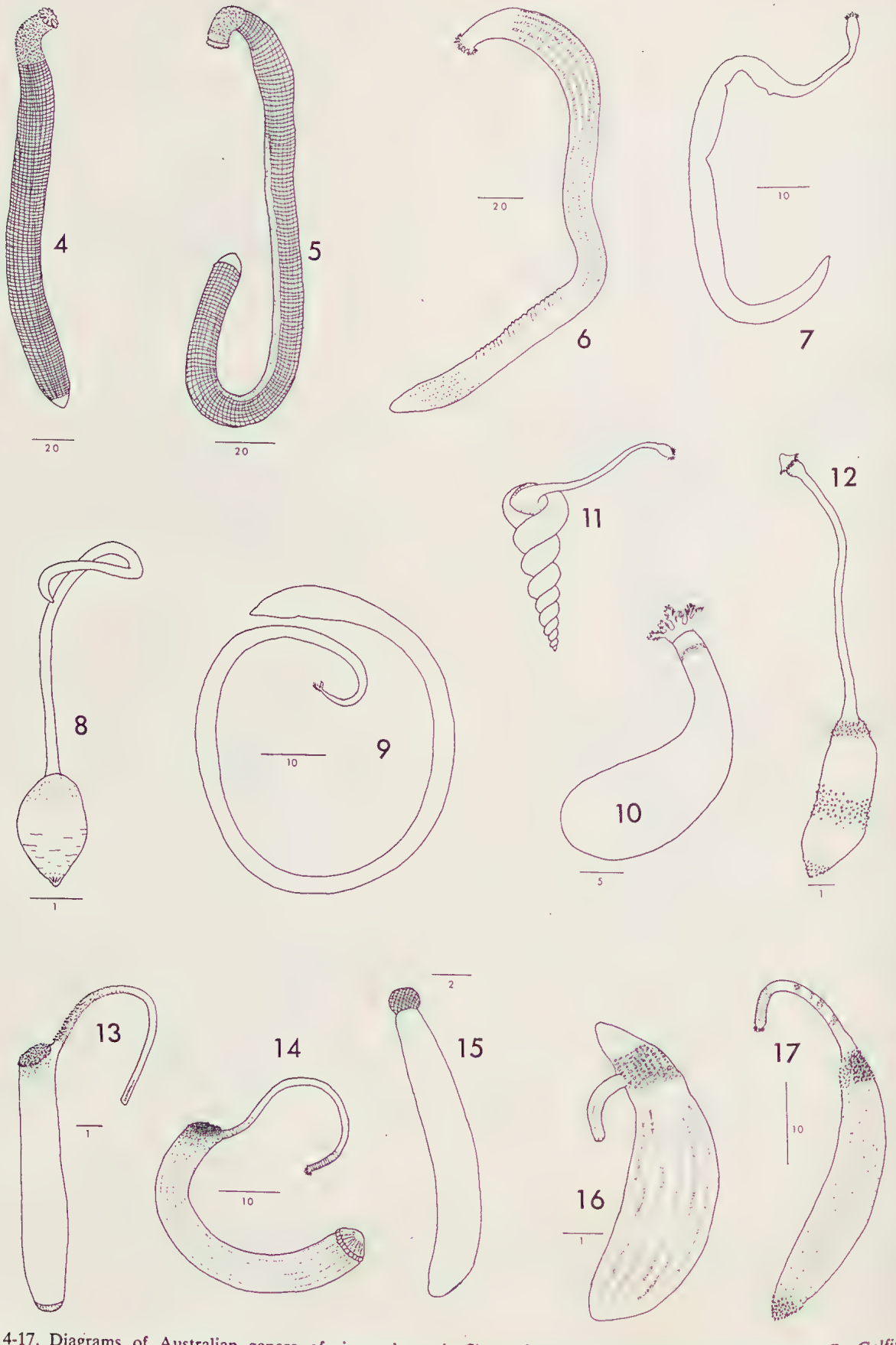
Previous systematic studies of Australian sipunculans

Records of sipunculans from Australia are contained in the following: Stimpson (1855), Keferstein (1865), Baird (1868), Selenka & de Man (1883), Augener (1903), Kesteven (1903), Fischer (1914, 1919a, 1921, 1927), Monro (1931), Wheeler (1938), Edmonds (1955, 1956), Murina (1964a, 1972), Cutler (1977) and Gibbs (1978).

More general information about the systematics of the phylum is given in Hyman (1959), Tétry (1959), Fisher (1952), Stephen & Edmonds (1972), Cutler (1973) and Cutler & Murina (1977).



FIGS. 1-3. Diagrams showing some of the external and internal characters of sipunculans. The specimen in Fig. 1 has been dissected from the dorsal side. a, anus; as, anal shield; c, caecum; cm, circular muscle; cs, caudal shield; cv, contractile vessel; dr, dorsal retractor; f, fastening muscles; g, gonad; h, hooks; i, introvert; in, intestine; lm, longitudinal muscle; m, mesentery; md, mid-dorsal line; mo, mouth; n, nephridia; nc, nerve cord; np, nephridiopore; o, oesophagus; p, papillae; r, rectum; sm, spindle muscle; t, tentacles; tf, tentacular fold; tp, triangular papillae; tr, trunk; vr, ventral retractor; wm, wing muscle.



FIGS. 4-17. Diagrams of Australian genera of sipunculans; 4, *Sipunculus*; 5, *Xenosiphon*; 6, *Siphonosoma*; 7, *Golfingia*, 8, *Onchnesoma*; 9 & 10, *Themiste*; 11, *Phascolion* (in shell); 12, *Phascolion* (removed from shell); 13, *Aspidosiphon*; 14, *Paraspidosiphon*; 15, *Cloeosiphon*; 16, *Lithacrosiphon*; 17, *Phascolosoma* (The numbers along the scale give its length in mm)

Australian collections of sipunculans

Collections of sipunculans are held in the Museums of all the States of Australia. The largest are those in the Australian Museum, Sydney and the South Australian Museum, Adelaide. A list of all the specimens in the latter Museum and their registered numbers is available on application to the Museum.

In the present paper the following abbreviations are used in referring to the collections: AMS—Australian Museum, Sydney; SAM—South Australian Museum, Adelaide; NMV—National Museum Victoria, Melbourne; WAM—Western Australian Museum, Perth; TM—Tasmanian Museum and Art Gallery, Hobart; QM—Queensland Museum, Brisbane. The number in brackets in the reference gives the number of specimens in the collection.

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II. SYSTEMATICS

Phylum Sipuncula and list of species reported from Australia

The characters of the phylum are stated on p. 2. (Specific names are in alphabetical order and Australian specimens of the species marked * have not been seen by me).

Family Sipunculidae

Sipunculus indicus Peters
Sipunculus robustus Keferstein
Sipunculus titubans titubans Selenka & de Man
Xenosiphon mundanus (Selenka & de Man)
**Siphonosoma australe* (Keferstein)
Siphonosoma boholense (Selenka & de Man)
Siphonosoma cumanense cumanense (Keferstein)
Siphonosoma novaepommeraniae Fischer
Siphonosoma rotumanum (Shipley)
Siphonosoma vastum (Selenka & de Man)

Family Golfingiidae

**Golfingia coriacea* (Keferstein)
Golfingia herdmani (Shipley)
**Golfingia improvisa* (Théel)
Golfingia margaritacea adelaidensis Edmonds
**Golfingia minuta* (Keferstein)
Golfingia misakiana (Ikeda)
**Golfingia murinae murinae* Cutler
**Golfingia ohlini* (Théel)
**Golfingia pellucida* (Keferstein)
Golfingia schuettei (Augener)
**Golfingia semperi* (Selenka & de Man)
Golfingia trichocephala (Sluiter)
Golfingia vulgaris queenslandensis Edmonds
Phascolion collare Selenka & de Man
Phascolion cronullae n.sp.
**Phascolion dentalicolum* Sato
**Phascolion pacificum* Murina
Themiste cymodoceae (Edmonds)
Themiste dehamata (Kesteven)
Themiste fusca (Edmonds)
Themiste huttoni (Benham)
Themiste lageniformis Baird
Themiste variospinosa n.sp.
**Onchnesoma steenstrupii* Koren & Danielssen

Family Aspidosiphonidae

Aspidosiphon elegans elegans (Chamisso & Eysenhardt)
**Aspidosiphon exhaustus* (Sluiter)
Aspidosiphon gracilis Baird
Aspidosiphon hartmeyeri Fischer
Aspidosiphon inquilinus Sluiter
Aspidosiphon jukesii Baird
**Paraspidosiphon cumingii* (Baird)
Paraspidosiphon formosanus (Sato)
Paraspidosiphon johnstoni n.sp.
**Paraspidosiphon steenstrupii* (Diesing)
Cloeosiphon aspergillus (Quatrefages)
Lithacrosiphon cristatus (Sluiter)

Family Phascolosomatidae

Phascolosoma albolineatum Baird
Phascolosoma annulatum Hutton
Phascolosoma arcuatum (Gray)
Phascolosoma nigrescens Keferstein
**Phascolosoma nigritorquatum* (Sluiter)
Phascolosoma noduliferum Stimpson
Phascolosoma pacificum Keferstein
Phascolosoma perlucens Baird
Phascolosoma rottnesti Edmonds
Phascolosoma scolops (Selenka and de Man)
Phascolosoma stephensoni (Stephen)

KEY TO FAMILIES OF SIPUNCULA
(based on Fisher, 1952 and Stephen and Edmonds, 1972)

1. Horny, chitinous or calcareous shield, cone or cap present at anterior extremity of trunk. Longitudinal musculature of body wall may form bands or be continuous
Aspidosiphonidae[‡] (p. 43)

No horny or calcareous shield, cone or cap present at anterior region of trunk 2

2. Tentacles basically surround mouth and may be simple or branched, lie in groups, be reduced to a few lobes or even be absent but not lying in a horseshoe-shaped ring dorsal to mouth. Nuchal organ, if present, is dorsal to tentacles and not enclosed by them 3

Tentacles arranged in a horseshoe-shaped ring which does not surround mouth but lies dorsal to it and which encloses the nuchal organ, if present. Longitudinal muscles grouped into bundles, except in one genus of four species. Skin usually bearing conical to hemispherical papilliform glands, usually largest and most prominent at anterior and posterior extremities of trunk. Phascolosomatidae (p. 55)

3. Longitudinal musculature of body wall thickened to form well defined bands. Integumentary canals or coelomic sacs present in body wall (except in that of one species)
Sipunculidae (p. 8)

Longitudinal musculature of body wall continuous and not thickened into bands ..... Golfingiidae (p. 18)

Family Sipunculidae and key to genera

Sipunculidae Baird, 1868 (in part); Sedgwick, 1898 (in part); Stephen and Edmonds, 1972.

Description: Adult specimens large and cylindrical. Longitudinal musculature always in bundles. Retractor muscles always four (except in *Siphonomecus*). Mouth surrounded by a ring of tentacles or a tentacular fold. Body wall of adults with integumental canals or coelomic sacs (except in *Phascolopsis*). Nephridia two. Type genus: *Sipunculus* Linnaeus.

Key to genera of the Sipunculidae

1. Introvert with sub-triangular, scale-like papillae but without hooks. Skin of trunk marked into rectangles by intersecting bands of longitudinal and circular muscles 2

Introvert without sub-triangular, scale-like papillae. Hooks or spines may be present. Skin not strongly marked off into rectangles (except in *Siphonomecus*) 3

2. Four retractor muscles and an additional pair of protractor muscles, the latter arising from body wall near anus and connecting with introvert near brain. Spindle muscle arises anteriorly from wall of rectum. Gonad in form of a fine loop attached to body wall and rectum
Xenosiphon Fisher (p. 12)

Four retractor muscles but no protractors. Spindle muscle arising from body wall anterior to anus. Gonads at base of ventral retractors and not in form of a filamentous loop
Sipunculus Linnaeus (p. 4)

3. Four retractor muscles 4
Two retractor muscles ..... *Siphonomecus* Fisher[†]

4. Spindle muscle not fixed to body wall posteriorly. No coelomic extensions in body wall. Introvert without hooks or spines ..... *Phascolopsis* Fisher[†]

Spindle muscle fixed posteriorly. Coelomic sacs or canals present in body wall. Introvert spines or hooks present or absent ..... *Siphonosoma* Spengel (p. 14)

[†]Dr. P. E. Gibbs of the Marine Laboratory at Plymouth, England has correctly pointed out to me (personal communication) that the tentacles of *Aspidosiphon* and *Paraspidosiphon* lie in a horseshoe-shaped ring dorsal to the mouth, as in *Phascolosoma*. The statements of Stephen and Edmonds (1972: p. 19, 215-216, 238) about the condition of the tentacles in Aspidosiphonidae, *Aspidosiphon* and *Paraspidosiphon* are therefore wrong and must be corrected. I am indebted to Dr. Gibbs for his information. Dr. Gibbs (1977: p. 30) has recently referred to the condition of the tentacles in *Aspidosiphon muelleri* Diesing.

Genus **Sipunculus** Linnaeus

Sipunculus Linnaeus, 1776 p. 1078; Fisher, 1952 p. 375; Stephen & Edmonds, 1972 p. 21.

Description: Usually large animals, often stout. Trunk cylindrical and usually divided into squares or rectangles by intersection of longitudinal and circular muscles. Introvert short, clearly differentiated from trunk and carrying numerous, flat triangular papillae. Mouth surrounded by a tentacular fold, the margins of which in living specimens form more or less distinct tentacles. Introvert lacks hooks and spines. Spindle muscle attached anteriorly in front of anus. Coelomic extensions present in body wall. Contractile vessel double. Post-oesophageal or "sipunculus" loop present in alimentary canal anterior to intestinal spiral. Paraneural muscle well developed. Type species: *Sipunculus nudus* Linnaeus 1776.

Key to species of **Sipunculus** known from Australia

1. Longitudinal muscle in 37-43 bands; trunk very long and rather slender ..... *S. indicus* (p. 9)

Longitudinal muscles in less than 37 bands; trunk usually stout 2

2. Longitudinal muscles in 27-30 (usually 29) bands; digitate processes of brain rather threadlike and lateral in position ..... *S. robustus* (p. 9)

Longitudinal muscles in 23-26 bands; digitate processes short, finger- to leaf-like rather than threadlike
S. titubans titubans (p. 10)

Remarks: Triangular, scale-like papillae are always present on the introvert of *Sipunculus* and *Xenosiphon* but not *Siphonosoma*. In *Xenosiphon* two protractor muscles are present and the gonads lie on a filamentous loop but not in *Sipunculus* nor *Siphonosoma*. The spindle muscle of *Siphonosoma* arises anteriorly from three roots and is fixed posteriorly to the trunk wall. In *Sipunculus* and *Xenosiphon* it arises anteriorly from a single root and is not fixed posteriorly.

Fischer (1914 p. 1) and Murina (1972 p. 307) identified single specimens from St. Vincent Gulf, South Australia as *Sipunculus nudus* Linnaeus. Because *S. robustus* is commonly collected in this Gulf (see p. 10) there is some doubt about their records.

[‡] Species of this genus not reported from Australia.

Sipunculus indicus Peters

Sipunculus indicus Peters, 1850 pp. 382-383; Keferstein, 1865 p. 421, pl. 31, fig. 1; Selenka and de Man, 1883 pp. 111-112; Edmonds, 1971 p. 137; Stephen and Edmonds, 1972 pp. 27-28.

Location of type: not known to author; specimen from Mozambique.

Description: Specimen long and cylindrical. Length of trunk 410 mm and width, almost uniform, 12 mm. Posterior extremity slightly rounded and swollen; invaginated terminal organ present. Surface of trunk divided into small rectangular areas by intersection of circular and longitudinal muscles. Circular annulations of trunk very noticeable. Surface of introvert bears sub-triangular papillae.

Longitudinal musculature in 37-42 anastomosing bands. Four retractor muscles arise at about the same level, the ventral pair from muscles 2-4 and the dorsal pair from 9-13 or 10-14. Alimentary canal with well developed post-oesophageal loop. Anus opens anteriorly to nephridiopores. Rectum long and fixed to body wall for most of its length. Small caecum attached to rectum. Two long nephridia, opening between muscles 4-5, extend back past point of fixation of rectractors and are attached to body wall for most of their length. Brain simple and lacking a tufted organ. Contractile vessel double.

Systematic position: Johnston (1969: p. 43) described *Xenosiphon (Xenopsis) indicus* from the Laccadive Is. The species has two rectractor and two protractor muscles arising from the body wall at different levels (Johnston 1969, fig. 3). Since he does not refer to *Sipunculus indicus* Peters and does not raise the question of synonymy it looks as if Johnson's "*indicus*" and Peter's "*indicus*" are different.

The Western Australian specimen, although it shows similarities with *Xenosiphon indicus* Johnson, is being described as *S. indicus* Peters because it lacks protractor muscles. Its four retractors arise from the body wall at about the same level. In addition the brain is simple and lacks the "tufted organs" described for *X. indicus*.

S. indicus is long and cylindrical. It possesses about 40 longitudinal muscles and the anus lies in front of the nephridiopores. Brain without processes, thus differing from *S. robustus* and *S. titubans*. Good illustrations of the species are given in Keferstein 1865, pl. 31, fig. 1 and in Sato 1939, pl. 19, fig. 4. No previous Australian record.

Distribution: (1) in Australia: Western Australia at Exmouth Gulf.

(2) elsewhere: Zanzibar, Madagascar, South Africa, Billiton, South China Sea, West Caroline Is., Coral Sea (AMS W5734).

Specimens examined and locality: Western Australia—Yardia Creek near Exmouth Gulf (1) AMS W9250.

Sipunculus robustus Keferstein

(Figs. 18, 20-22)

Sipunculus robustus Keferstein, 1865 p. 421; Stephen and Edmonds, 1972 pp. 36-37.

Sipunculus angasii Baird, 1868 p. 80; Edmonds 1955 pp. 83-86, figs. 1-4, pl. 1.

Location of type: Hamburg Museum; specimen from Uvea (Wallis Is.), Pacific Ocean.

Description: Specimens long, cylindrical and often stout; frequently washed up on beaches near Adelaide after early winter storms. Colour pale pink and slightly iridescent. Trunk 60-260 mm long, 8-20 mm wide and usually divided into small, rectangular areas by intersection of circular and longitudinal muscles. Introvert short, clearly differentiated from trunk, 15-30 mm long and 5-10 mm wide, with numerous, posteriorly directly, scale-like papillae but no hooks. Mouth surrounded by a wrinkled fold, which in living specimens more closely resembles finger-like tentacles. Posterior extremity of trunk usually rounded and swollen but sometimes pointed. Terminal organ present.

FIG. 18. *Sipunculus robustus*, (specimen from Tasmania), (scale measurements are in mm).

Longitudinal muscles in 27-30 (usually less than 30), sometimes anastomosing, bundles. Four stout, equal retractors arise at same level in anterior third of trunk, ventral pair from muscles 3-5 (2-5, 2-6, 3-6) and dorsal from 9-11 (9-12, 10-12, 8-13). Anterior region of oesophagus fastened to dorsal retractors by thin mesenteries and rest of gut to body wall by thin threads. Post-oesophageal or "sipunculus" loop present in foregut. Racemose glands and caecum present. Spindle muscle arises anterior to anus but not fixed posteriorly. Contractile vessel double. Nephridia attached between muscles 4 and 5 (5-6, 6-7) anterior to anus. Bilobed brain gives off dorso-laterally a number of delicate, thread-like digitate processes.

Systematic position and remarks: Edmonds (1955) identified a common South Australian sipunculan as *Sipunculus angasii* Baird 1868, a species described from Port Lincoln, South Australia. After an examination of the holotype of *S. robustus*, Stephen and Edmonds (1972: p. 37) concluded that *S. robustus* and *S. angasii* are conspecific, the name *robustus* having priority. *S. robustus* is well known in the Indo-Pacific region.

A comparison made between about 50 specimens of *S. nudus* collected by me at Morgat, Brittany (France) during 1961 and about 50 specimens of *S. robustus* collected from South Australian beaches confirms that the two species, although closely related, are different. In *S. nudus* there are 28-32 (usually over 30) longitudinal muscles while in *S. robustus* there are 27-30 (usually 28-29). In *S. robustus* the digitate processes are rather threadlike and somewhat lateral in position. In *S. nudus* they are fewer, short, rounded to fingerlike and situated more dorsally. The retractors in *S. nudus* usually span six or seven longitudinal muscles while in *S. robustus* it is usually three or four.

Fischer (1914 p. 1) identified *S. nudus* from St. Vincent Gulf, South Australia and Murina (1972 p. 307) *S. nudus* from Adelaide. Both records are of single specimens. It seems likely that the specimens are what I would call *S. robustus*.

S. robustus in South Australia lives below the level of low tide on sandy beaches. The gut contents are usually sand. Two small specimens were collected from the gut contents of a fish, *Sillaginodes punctatus*, caught at Marion Bay, South Australia (SAM E1072). The body fluid of *S. robustus* like that of *S. nudus* contains, in addition to blood cells and amoebocytes, free swimming, ciliated urn cells which are thought to help in the removal of some waste materials from the animal.

Previous Australian records: Monro (1931), Augener (1903), Edmonds (1955), Gibbs (1978).

Distribution: (1) in Australia: Queensland, Victoria, Tasmania, South Australia and West Australia.

(2) elsewhere: Palau, Wallis Is., West Caroline Is., Marshall Is., Philippines, Indonesia, Maldive and Laccadive Is., Madras, Madagascar, Zanzibar, off South Africa (at 2 720 m) and Malacca St. (at 1 140 m).

Specimens examined and localities: Queensland —Low Is. (1) SAM E1060 and (1) (Dr. P. Gibbs) SAM E1057; Turtle Is. (1) (Dr. P. Gibbs) SAM E1057; Townsville (1) E1052; Line Is. AMS G11388; Hayman Is. (1) AMS W3131. Victoria—Port Arlington (1) NM G1125; Black Rock (1) NM G1126; Hobsons Bay (1); Queenscliff (1) NM G1124; Rosebud (1) NM G1128; Brighton (1) NM G1123; Portland (1) SAM E1049. Tasmania—Seven Mile Beach (1) SAM E1048 and (2) TM K103/15530. South Australia—St. Vincent Gulf (washed up after storms), especially at Aldinga and Sellicks Beaches (80) SAM E1050, E1051, E1053 and E1055; Spencer Gulf at Minlacowie (2) SAM E1054; Aldinga Beach (2) AMS W3600. Western Australia—Rottnest Is. (1) WAM 125/76; Woodmans Point (1) WAM 172/76.

Sipunculus titubans titubans Selenka & Bulow

(Figs 23-25)

Sipunculus titubans Selenka & Bulow, 1883 pp. 100-101; Stephen & Edmonds, 1972 pp. 37-38.

Location of type: Zoological Museum, Humbolt-University of Berlin, DDR.; specimen from Puntarenas (coll. Grübe), cat. no. 1036.

Description: This account is based on 12 specimens, two larger ones from the Gulf of Carpentaria and 10 smaller ones from Moreton Bay, Queensland. All are cylindrical with body wall divided into rectangles by the crossing of longitudinal and circular muscles. Body wall of larger specimen thick but of smaller pink and semi-transparent. Trunk of larger 80-120 mm long and 8-11 mm wide, of smaller 18-55 mm long and 2-5 mm wide. Posterior extremity pointed, rounded or formed into a glans. Invaginated terminal organ present in two. Introvert short (maximum length 10 mm), much narrower than trunk and bearing numerous, fleshy, sub-triangular papillae. Tentacles not exposed in any specimen but dissection shows that a tentacular fold is present.

Longitudinal muscles in 23-26 bands (usually 24 at base of retractors), anastomosation slight. Four introvert retractors arising at same level in anterior fourth of trunk. Base of retractors usually extended laterally by strands of muscular tissue (making it difficult sometimes to specify the span of the muscles). Ventral retractors arising from muscles 2-5, 1-4, 1-5 or 1-6, dorsal retactors from 6-10, 6-11, 7-11 or 8-11. Anterior oesophagus attached to dorsal retractors by thin mesenteries and post-oesophageal loop present in foregut. Rectum short and rectal caecum present in two larger specimens and two smaller ones. Two racemose glands attached to strands of tissue connecting rectum and base of dorsal retractors. Contractile vessel double with roughened or vesiculated surface but no tubular villi. Spindle muscle arises anterior to anus but not fixed posteriorly. Nephridia about one fourth or fifth as long as trunk, arising between muscles 4-5 well in front of anus and attached for about a fourth or fifth of their length. Brain bilobed with a number of short digitate processes along its anterio-dorsal margin; processes may be simple, stubby or leaf-like and those laterally placed may branch slightly.

Systematics: At first I thought that these specimens might be *Sipunculus aequabilis* Sluiter, 1902 described from Indonesia. A re-examination of the holotype (Zoological Museum, Amsterdam)—an already dissected specimen—confirms that it has 21-22 longitudinal muscles, that its ventral retractors arise from muscle number 3 and the dorsal pair from 8-9. It has a small caecum but no racemose glands. The specimens from Queensland however, possess a greater number of longitudinal muscles and their retractors span more muscles. One point not previously reported is that at least three stout swellings or protuberances arise from the fore-brain of the holotype of *S. aequabilis*. I am inclined to think that they correspond to digitate processes.

Although resembling *Sipunculus norvegicus* (Danielssen, 1869) in many respects the Queensland specimens differ because they possess digitate processes. Recently I examined two specimens of *S. norvegicus* from the collection of the British Museum (Nat. Hist.)—one from Norway (1922-5-22-1) and the other from the Bay of Biscay (97-4-21-4). The brain of both lacks digitate processes. Confirmatory evidence on this point is given by Akesson (1958 p. 138); "At about the place where the other species *(S. nudus* and *S. robustus)* have digitate processes *S. norvegicus* has a muscular strand, a rudiment of the larval protractor muscle. There is certainly no histological similarity between the two structures and they are not connected in any way."

Sipunculus titubans Selenka & Bülow, 1883 was described from a single specimen collected at Puntarenas. Recently I examined the holotype, a dissected specimen. The trunk is about 48 mm long and the introvert 6 mm. A tentacular fold surrounds the mouth and triangular papillae are present on the introvert. Longitudinal muscles 26 at base of retractors and 26 posteriorly. Ventral retractors arise from muscles 1-5, 1-6 (type description says 3-5 or 1-5) and dorsals from 8-11, 7-11. Racemose glands and caecum present. Contractile vessel double. Nephridia opening anteriorly to anus between muscles 4-5 and fixed for half their length. As stated in the type description, no spindle muscle is present but the intestine has been damaged and part of it is missing. Brain bilobed and giving off from its anterio-dorsal margin a number of short tufted (possibly leaf-like) digitate processes, something not mentioned by Selenka (unless included in the statement "Nervensystem demjenigen *S. nudus* sehr ahnlich").

Consequently I consider the specimens from Queensland to be *S. titubans*. The chief differences are that in the holotype (1) the digitate processes seem to form a tufted or brush-like structure while in the others the processes are stouter and (2) the nephridia are fixed for half and not a fifth of their length. The absence of a spindle muscle in the holotype is so unusual in *Sipunculus* that it may reasonably be regarded as accidental and not general. Unfortunately no reference to the absence or presence of a spindle muscle in their specimens of *S. titubans* has been made, as far as I can see, by other authors.

The Queensland specimens differ from *Sipunculus robustus* Keferstein which has 27-29 longitudinal muscles and longer and more thread-like digitate processes and from *Sipunculus nudus* Linnaeus which has 30-33 muscles and finger-like processes. *Sipunculus zenkevitchi* Murina, 1969, dredged from the Pacific Ocean, has 25 longitudinal muscles, an oval brain with two eyespots but apparently no processes. *Sipunculus longipapillosus* Murina, 1968 has 24-26 longitudinal muscles but trunk papillae with long extensions. *Sipunculus delphinus* Murina, 1967 has 25 longitudinal muscles, retractors arising from muscles 2-5 (2-4) and 7-8 (8-11), a caecum and racemose glands and seems very closely related to *S. titubans*.

What evolutionary or adaptive value the different kinds of digitate processes have in the Sipunculidae is not known. Metalnikoff (1900) considered that the processes were sensory structures. Akesson (1958 p. 136) maintains that they are not sensory but "form a part of a secretory organ. In the organ is accumulated the neurosecretory substance from the bipolar neurosecretory cells in the anterior dorsal margin of the brain. From there the secretion is given off to the coelomic fluid".

Digitate processes have been found, at least, in the following *Sipunculus* species; *S. nudus* Linnaeus (finger-like), *S. robustus* Keferstein (thread-like), *S. titubans* Selenka & Bulow (brush-to finger-like), *S. galapagensis* Fisher (irregularly folded sheets of tissue), *S. marcusi* Ditadi (leaf-like), *S. natans* Fisher (numerous slender lobes forming a conspicuous tuft) and *S. polymyotus* Fisher (very slender, flattened, thin and digitate). Three or four swellings or protuberances on the forebrain of the holotype of *S. aqeuabilis* Sluiter are probably processes. The processes are lacking in *S. norvegicus* Danielssen.

Fischer, 1895 described a subspecies, *S. titubans diptychus,* from West Africa which has 30-33 muscle bands, retractor muscles attached to bands 2-5 and 11-14 and a spindle muscle.

No previous record from Australia.

Distribution: (1) in Australia: Queensland at Weipa and Moreton Bay.

(2) elsewhere: North-west Africa, Canary Is., Gold Coast Gulf of Guinea, Senegal, Zanzibar, Madagascar, Gulf of Siam, Thailand, West Indies, southern Chile.

Specimens examined and localities: Queensland —Weipa (Albatross Bay, Gulf of Carpentaria) (1) AMS W9241; mouth of Embley River (Albatross Bay) (1) WAM 231/76; Middlebanks (Moreton Bay) dredged in sandy mud at 10 m (10) SAM E1069.

Genus **Xenosiphon** Fisher

Xenosiphon Fisher, 1947 p. 360; 1954 p. 312; Stephen & Edmonds, 1972 p. 38; Johnston, 1969 p. 43.

Type species: *Xenosiphon branchiatus:* Fisher, 1947.

Description: Large, cylindrical and closely resembling *Sipunculus.* Unlike *Sipunculus* in possessing an extra pair of protractor or retractor muscles, arising from posterior border of introvert near brain. Introvert short and with flat, triangular papillae. Longitudinal and circular muscles banded as in *Sipunculus.* Rectum long and anus lies anterior to nephridiopores. Gonads form a filamentous loop. Integumental canals or sacs present.

Type species: *Sipunculus mundanus branchiatus* Fischer, 1895.

Remarks: Four species have been described for the genus. They fall into three subgenera; (1) *Xenosiphon* (sensu stricto) Fisher, 1954 p. 312.

Subcutaneous coelomic system consists of independent, irregular sacs, some of which carry papilliform gills. No accessory intestinal loop. Nephridia long and attached to body wall by mesentery. *X. caribaes* Fisher, 1954 also belongs to this subgenus.

(2) *Austrosiphon* Fisher, 1954

Type species: *Xenosiphon mundanus* (Selenka & Bulow, 1883).

Subcutaneous system in form of longitudinal canals lying between longitudinal ridges of body wall. Accessory or "sipunculus" loop present in foregut. Nephridia small and free.

(3) *Xenopsis* Johnson, 1969

Type species: *Xenosiphon indicus* Johnson, 1969.

Subcutaneous system as in Austrosiphon. Two protractors and only one pair of retractors. "Sipunculus" loop present in foregut. No cephalic tube.

In Australia only one species, *Xenosiphon mundanus,* is known.

Xenosiphon (Austrosiphon) mundanus (Selenka and de Man)

(Figs. 26-27)

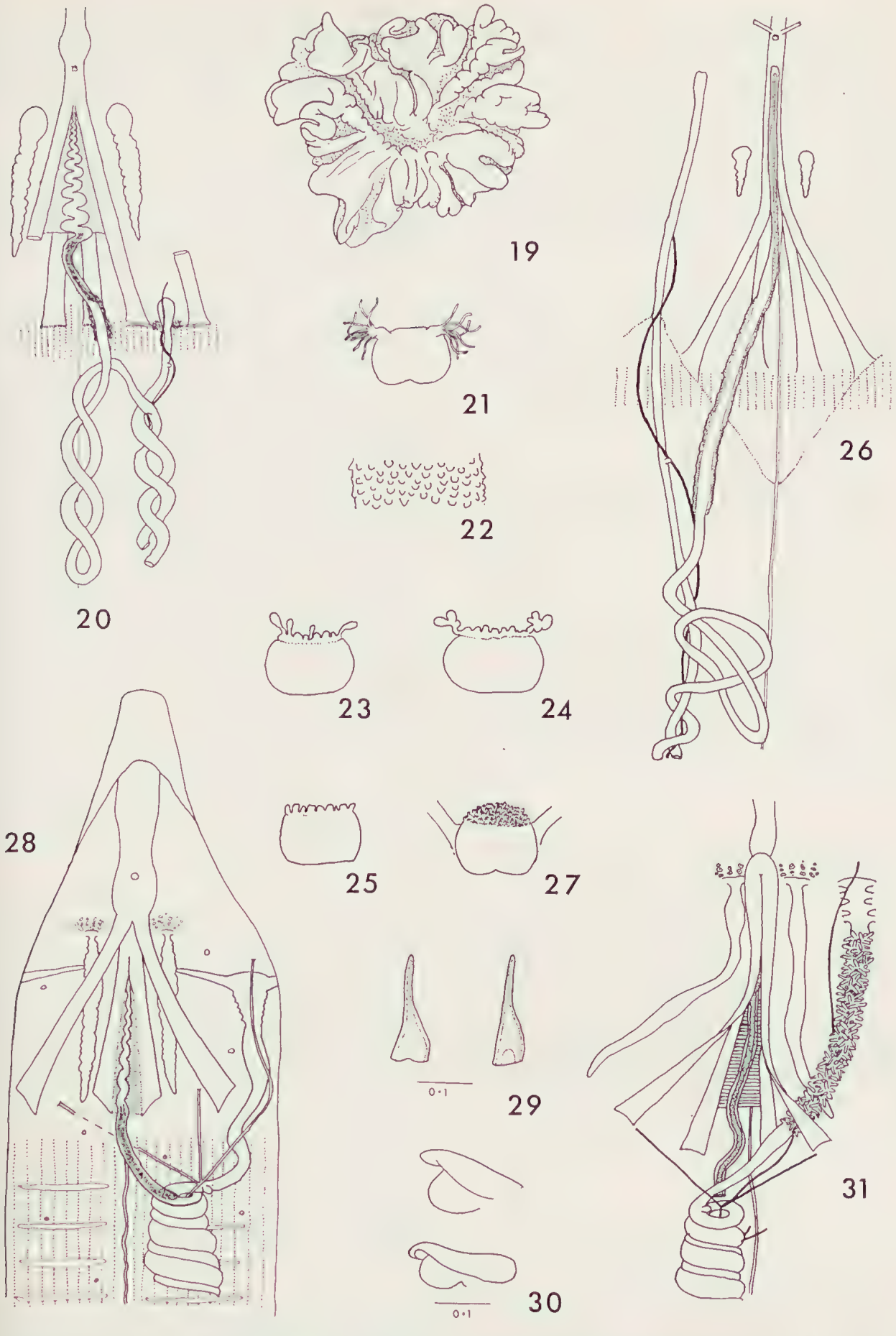
Sipunculus mundanus Selenka and de Man, 1883 pp. 108-109, pl. 12, fig. 174.

Xenosiphon mundanus Fisher, 1954 p. 314; Edmonds, 1955 pp. 87-89; Edmonds, 1960 p. 160; Cutler, 1977 p. 138.

Location of type: British Mus. (Nat. Hist.), London; specimen from Sow and Pig Shoal, Port Jackson, New South Wales.

Description: Specimens long, cylindrical and superficially resembling a *Sipunculus.* Trunk 130-270 mm long and 7-12 mm wide. Body wall divided into rectangular areas by intersecting bands of longitudinal and circular muscles. Introvert short, 10-20 mm long and 4-7 mm wide, bearing many, posteriorly directed, scale-like papillae and a tentacular pad or fold. Annulations caused by circular muscles usually less marked on dorsal surface of posterior third of worm. Longitudinal muscles in 28-31, slightly anastomosing bands. Terminal organ present at posterior extremity of trunk.

Four retractor muscles arise at about same level, a ventral pair from muscles 2-4, 1-3, 1-4 and dorsal pair from 7-10, 7-11, 8-11. Two ribbon-like protractor muscles arise from body wall of anterior part of trunk and are attached to introvert near brain. Oesophagus long and straight; short post-oesophageal or "sipunculus" loop present. Spirals of intestine fastened by many short mesenteric threads.



FIGS. 19-31. Fig. 19, tentacular fold of a *Sipunculus* (after Gibbs). Figs. 20-22, *Sipunculus robustus;* 20, anterior region dissected; 21, brain and digitate processes; 22, subtriangular papillae from introvert. Figs. 23-25, *Sipunculus titubans titubans;* brain and processes of three specimens from Queensland; Figs. 26-27, *Xenosiphon mundanus;* 26, anterior region dissected; 27, brain and tufted processes (after Fisher). Fig. 28, *Siphonosoma cumanense;* anterior region dissected. Fig. 29, *Siphonosoma australe;* hooks. Fig. 30, *Siphonosoma rotumanum;* hooks. Fig. 31, *Siphonosoma vastum;* anterior region dissected.

Anal aperture lies well anterior to nephridiopores. Rectum long and attached to body wall. Small caecum present. Contractile vessel double.

Gonads in form of a fine, delicate loop of tissue arising on each side of rectum and running across body wall to base of retractors and nerve cord. Nephridia short, stout and free, opening between muscles 4-5. Integumental canals lie longitudinally between ridges of muscles. Brain bilobed and capped anteriorly with a pad of tufted tissue.

Systematic position: This species is well known in south-eastern Australia and New Zealand. Its distinctive features are its two protractor muscles, its long rectum, its short nephridia (in *X. branchiatus* they are long) and the position of the anus well anterior to the nephridiopores. *X. indicus* Johnson, 1969 from the Laccadive Is. possesses 40-45 longitudinal muscles.

Previous Australian records: Selenka and de Man (1883); Edmonds (1955); Cutler (1977).

Distribution: (1) in Australia: New South Wales, Lord Howe Is., Victoria and off coast of South Australia at 1 320 m (Cutler 1977).

(2) elsewhere: New Britain; New Zealand; Chile (Tarifino and Tomicic, 1973).

Specimens examined and localities: New South Wales—Gunnamatta Bay (1) SAM E1083; Pig and Sow Shoal, Port Jackson (2) SAM E1080; Lord Howe Is. (2) AMS G3950 and W1873; Bermagui (2) AMS W2534; Botany Bay (1) AMS W2535; Balmoral Beach (1) W1665. Victoria—Queenscliff (1) SAM E1085; Portland (1) NMM G1217; Port Fairy (4) AMS W9249. Tasmania—Binalong Bay (1) TM K825.

Genus **Siphonosoma** Spengel

Siphonosoma Spengel, 1912 p. 264; Fisher 1950a p. 805; 1952 pp. 380-381; Stephen and Edmonds 1972 p. 43.

Type species: *Siphonosoma australe* (Keferstein, 1865).

Description: Adults usually large and cylindrical. Introvert often not well differentiated from trunk and lacking scale-like, triangular papillae but sometimes possessing hooks and spines. Tentacles thread-or finger-like; no tentacular fold. Longitudinal muscles always divided into bands (sometimes not readily noticed from outside). Coelomic sacs in body wall. Four retractors. Spindle muscle arises anteriorly from three roots and attached posteriorly to body wall. Contractile vessel single and dorsal; small contractile tubules usually present. Two nephridia (usually with large crescentic nephrostomes). No post-oesophageal loop.

Subgenera: Fisher (1950a p. 805) divided the genus into three subgenera.

TABLE 1.

SUBGENERA OF *SIPHONOSOMA*

Subgenus	Transverse dissepiments	Numerous rectal caeca	Type species
Siphonosoma s.s	absent	absent	*S. australe* (Keferstein)
Hesperosiphon	absent	present	*S. vastum* (Selenka & de Man)
Damosiphon	present	absent	*S. cumanense* (Keferstein)

Remarks: Species of *Siphonosoma* can be distinguished from those of *Sipunculus* because (1) the introvert lacks scale-like papillae (2) the tentacles do not form a fold (3) the spindle muscle arises anteriorly from three roots and is fixed posteriorly and (4) no post-oesophageal loop is present in the foregut.

KEY TO AUSTRALIAN SPECIES OF *SIPHONOSOMA*

1. Numerous transverse dissepiments attached to coelomic wall of trunk . . *S. (Siphonosoma) cumanense cumanense* (p. 14)
   No transverse dissepiments attached to coelomic wall 2
2. Rectum with very numerous, finger-like caeca or villi *S. (Hesperosiphon) vastum* (p. 15)
   Rectum without finger-like caeca or villi 3
3. Introvert with hooks, spines or spine-like papillae 4
   Introvert without hooks, spines or spine-like papillae 5
4. Brown-black, slightly bent hooks present *S. (Siphonosoma) australe* (p. 16)
   Light-brown, blunt, papilla-like spines present *S. (Siphonosoma) rotumanum* (p. 18)
5. Longitudinal muscles 30-32 *S. (Siphonosoma) boholense* (p. 17)
   Longitudinal muscles about 20 *S. (Siphonosoma) novaepommeraniae* (p. 17)

Siphonosoma (Damosiphon) cumanense cumanense (Keferstein)

(Fig. 28)

Phascolosoma cumansense Keferstein, 1867 pp. 53-55, pl. 6, figs 19-21.

Sipunculus deformis Baird, 1868 pp. 80-81, pl. 9, fig. 2; Edmonds, 1955 p. 90.

Siphonosoma cumanense: Edmonds 1955 pp. 90-92; Stephen and Edmonds, 1972 pp. 46-49.

Location of type: Not known by author; specimen from Venezuela.

Description: Specimens of various size and shape; usually long and cylindrical. Length of trunk and maximum width of two largest specimens 410 x (10-20) mm, 450 x (12-21) mm, and of smallest 50 x (4-6) mm. Anterior region of trunk usually swollen. Introvert not strongly differentiated from trunk and for such a large species comparatively short; maximum length 60 mm, minimum 10 mm and lacking hooks and spines. Mouth surrounded by finger-like tentacles which, although numerous, seem small for the size of the animal. Anterior surface of trunk may be divided by furrows into small areas enclosing flat, glandular openings. Hemispherical papillae, with diameter up to 0·6 mm, on anterior and posterior surfaces of trunk; lying more or less in longitudinal rows and composed of long narrow plates with their long axes placed along the radii of the papillae. Body wall thick except where it is not traversed by circular and longitudinal musculature, such areas containing prolongations or extensions of the coelom.

Longitudinal muscles in 18-25 (usually 20-22) anastomosing bands. Four retractors arise in anterior fourth of trunk at about same level (sometimes dorsal pair a little more anteriorly), a ventral pair from muscles 2-3, 3-4, 1-3, 1-4 and a dorsal from 6-8, 7-8, 8-9. Sometimes retractors may lie obliquely along one or two muscles rather than transversally across a wider band.

Anterior region of oesophagus fixed to ventral retractors by thin mesenteries. Stout spindle muscle arises anteriorly from 3 roots, one anterior to anus and two from muscles 8, 9 or 10 near point of fixation of dorsal retractors. Two fasteners, arising from muscle 1 on each side of nerve cord, run to last spiral of intestine. Rectal caecum usually situated near point where 3 roots of spindle muscle meet. Two strands of muscle arise from muscle 1 at about level of nephrostomes, stretch across body wall and attach to wing muscle. Contractile vessel with numerous small villi. A series of thin crescentic shaped dissepiments lie transversally on each side of nerve cord between base of retractors and posterior extremity of trunk, spanning muscles 1-8, 3-7, 4-10 or 3-9. Two nephridia, attached to body wall for about a fifth of their length and extending to the base of the retractors, open between muscles 2-3 or 3-4 just anterior to anus. Tufted organs on coelomic wall near nephrostomes. Oval bodies, 0·8-1·5 mm in diameter, attached to inner body wall. Gonads at base of ventral retractors. Terminal organ present. Brain without processes.

Systematic position: These specimens possessing body dissepiments but lacking introvert spines and numerous rectal caeca fall into the subgenus *Damosiphon* Fisher, 1950a. They are being identified as *S. cumanense cumanense,* a species originally described from Venezuela and since reported from other tropical and warm waters. *Siphonosoma edule* Pallas, 1774, however, is a very closely related species, so close that it is not easy to decide on a character that distinguishes the two. The introvert of *S. edule* is said to be shorter than that of *S. cumanense.* The differences are discussed but not resolved in Stephen & Edmonds, 1972 P. 46 and 51. As *S. edule* was described from Batavia it is possible that some of these Australian specimens are *S. edule* (especially the specimen SAM E1090). A careful study of specimens collected from Batavia and Venezuela needs to be carried out, I think, before a decision about the two species can be made.

Previous Australian records: Baird (1868), Fischer (1921), Monro (1931), Edmonds (1955) and Gibbs (1978).

Distribution: (1) in Australia: East coast from Cape York to the mouth of the Clarence River, including the Great Barrier Reef; North West coast near Broome; West coast near Fremantle.

(2) elsewhere: East coast of America, Venezuela, Florida; Indian Ocean, Madagascar, Zanzibar, Red Sea, Arabian Sea, Laccadive and Maldive Is., Amboina; Pacific Ocean, New Guinea, Loyalty Is., New Britain, Philippines, Japan, Tahiti and Indo-China.

Specimens examined and localities: Queensland —Dunwich (in mud flats) (1) SAM E1090; same locality (1) SAM E1091 (2) SAM E1092, (1) SAM E1093, (1) SAM E1094; Low Is., (4) SAM E1096; Sir Charles Hardy Is., (11° 55' S, 143° 28' E) British Museum. New South Wales —Shelly Beach (mouth of Clarence River) (1) AMS W3194; Port Denman (3) AMS W1006. Western Australia—Kwinana (1) WAM 196/76; Fremantle Harbor (1) WAM 199/76; North West coast (1) Dept. of Zoology, Univ. of W.A.

Siphonosoma (Hesperosiphon) vastum (Selenka & de Man)

(Fig. 31)

Sipunculus vastus Selenka & de Man, 1883 pp. 103-104, fig. 171, fig. 179.

Siphonosoma crassum Spengel in Fischer, 1919a p. 279.

Siphonosoma vastum: Fischer, 1927 p. 199; Edmonds, 1955 pp. 92-95, figs 8-9; Stephen & Edmonds, 1972 p. 55-56.

Location of type: Zoological Museum of Humboldt University of Berlin; specimen from Jaluit (Marshall Is., Pacific Ocean).

Description: Trunk of Queensland specimen about 260 mm long and 10-13 mm wide and of Western Australia 57 mm long and 7 mm wide. Introvert, retracted in both specimens, 15-50 mm long; armed with numerous rows of curved, yellow-brown, rather blunt hooks or spinelets, the largest of which is about 0·1 mm long. Skin between rows of spines divided by fine furrows into small rectangular areas, each containing a small glandular opening. Surface of introvert and trunk bears hemispherical papillae, the largest (at anterior of trunk) being up to 0·5 mm in diameter.

Longitudinal muscles in 22-26 anastomosing bands. Two stout ventral retractors arise from muscles 2-6 or 1-6, and two dorsal retractors more anteriorly from muscles 9 or 9-10. Oesophagus attached to ventral retractors by fine mesenteries and gut filled with calcareous fragments. Contractile vessel with numerous small tubules or villi. Numerous larger fingerlike villi or caeca 1-1·5 mm long, attached to rectum; their function is unknown. Anal aperture between muscles 11-12 at about level of nephridiopores. Wing muscle strong. Stout spindle muscle arises anteriorly from 3 roots, one from muscle 12 anterior to anus and others from muscles 11 and 8. Another fastener from last whorl of intestine bifurcates, each root being attached to muscle 1 on each side of nerve cord. Spindle muscle attached posteriorly to body wall. A sac-like, globular, rectal or intestinal caecum, readily distinguishable from the numerous fingerlike villi, also present. Two nephridia, possessing prominent semi-lunar nephrostomes open between muscles 3 and 4, are attached for about a third of their length. Brain small and lacking processes.

Systematic position: The internal anatomy of these specimens resembles more closely that of *S. vastum* as shown in fig. 171 of Selenka & de Man, 1883 rather than that of *S. parvum* Fischer, 1928.

Previous Australian record: Shark Bay, Western Australia (Fischer, 1919a, 1927); Queensland (Edmonds, 1955).

Distribution: (1) Australian: Queensland at Heron Is. and Great Barrier Reef; Western Australia at Pt. Cloates.

(2) elsewhere: Pacific Ocean; Marshall Is., Funafuti, Rotuma, New Britain, Guam and Solomon Is. Indian Ocean; Mauritius, Laccadive Is., Maldive Is. Indonesia.

Specimens examined and localities: Queensland —Outer Barrier Reef (1) AMS W1606; Heron Is. (1) NMV coll.; Gillet Cay (4) AMS W9245. Western Australia—Point Cloates (1) WAM coll., Ningalloo Exped.

Siphonosoma (Siphonosoma) australe (Keferstein)

(Fig. 29)

Phascolosoma australe Keferstein, 1865 pp. 422-3, figs. 12 and 13.

Sipunculus australis Selenka and de Man, 1883 p. 90, figs. 180-183.

Siphonosoma australe Fisher, 1950a p. 807; Edmonds, 1961 pp. 217-220.

Sipunculus aeneus Baird, 1868 p. 76; Edmonds, 1961 pp. 217-220.

Location of type: Not known by author; specimen from Sydney, Australia.

Description: Although specimens of *S. australe* from New Zealand, Solomon Is. and south India have been examined by the author none are available from Australia. The following information is based on that of Keferstein (1865), Selenka and de Man (1883), Fischer (1922), Fisher (1950a) and Edmonds(1961).

Specimens long and cylindrical; trunk 130 mm (Keferstein)—220 mm (Fischer). Ratio of length of introvert to that of trunk half (Keferstein), third to half (Fischer) and almost three-quarters (Fischer). Prominent, hemispherical papillae on surface of trunk. Introvert armed with numerous rows of dark brown hooks or spines, 0·45 mm long (Keferstein), 0·22-0·34 (Edmonds), 0·3 (Fisher) and 0·2 (Fischer). Longitudinal muscles in 15 bands (Keferstein) but 13-18 according to other authors. Four retractor muscles arising at different levels in anterior third of trunk, a ventral pair from muscles 1-3 or 3-5 and a dorsal pair from 5-6 or 4-6. Nephridia long and free. Spindle muscle arises anteriorly from 3 roots and fastened posteriorly to body wall. Rectal caecum present.

Systematics: This species lacks both body dissepiments and numerous rectal caeca. It possesses rather long, dark spines. The differences between *S. australe* and the closely allied *S. eniwetoki* are discussed and illustrated in Fisher, 1950a. The hooks of *S. rotumanum*, another allied species, are stubby and rounded while in *S. australe* they are longer and sharper. Previous Australian record: Sydney, New South Wales (Keferstein, 1865).

Distribution: (1) in Australia: Sydney, New South Wales.

(2) elsewhere: Pacific Ocean; New Zealand, Samoa, Fiji, New Britain, Solomon Is., Philippines and Tasman Sea (at 610 m). Indian Ocean; Zanzibar, Madagascar, India and Indonesia.

Siphonosoma (Siphonosoma) boholense (Selenka and de Man)

Sipunculus boholensis (Semper?) Selenka and de Man 1883 pp. 109-111, pl. 12, figs. 175-177.

Siphonosoma boholense Stephen and Edmonds 1972 p. 63.

Location of type: Not known; specimen from Bohol (Philippines).

Description: Specimens very large and very stout. Trunk 270-410 mm long and 15-25 mm wide; maximum width anteriorly. Three specimens dark purple and fourth yellow brown. Body wall very thick. Introvert completely or partly contracted in all specimens; its maximum length about 80 mm and width 10-13 mm. A dissected introvert shows that numerous rows of brown papillae ring the organ but that hooks are absent. Base of introvert usually more darkly pigmented than rest of body. Skin of trunk anterior to anus rough and warty.

Longitudinal muscles in 29-33 anastomosing bands. Prominent rather flat papillae or skin bodies present on surface of trunk. Posterior extremity of 2 specimens is slightly bulbous and a terminal organ present. Four strong retractors arise in anterior third of trunk, a ventral pair from bands 4-5, 6-7, 4-6 and a dorsal pair more anteriorly from 9-12, 8-11, 8-13. Contractile vessel, with numerous very small villi, appears bushy. Spindle muscle stout; arises anteriorly from three roots, one being fixed in front of anus and others near base of dorsal retractors. Wing muscle strong. Rectal caecum in one specimen but not in second. Two nephridia, fixed to body wall for about two thirds of their length, open just in front of or at about same level as anus. Nephrostomes prominent and surrounded by numerous, small, tufted projections of the body wall. Prolongations of coelom extend into body wall. No fastener to last whorl of intestine found.

Systematic position: This is one of the largest species of sipunculans. It differs from other species of the same genus most noticeably in the number of longitudinal bands. In addition it lacks transverse dissepiments and hooks. This is the first Australian record.

Distribution: (1) in Australia: Queensland.

(2) elsewhere: Bohol, North Borneo.

Specimens examined and localities: Queensland—Yule Point, Townsville (3) SAM E1123; Dunwich (1) SAM E1124.

Siphonosoma (Siphonosoma) novaepommeraniae Fischer

Siphonosoma novaepommeraniae Fischer, 1926 pp. 104-106, pl. 3, figs 2-4; Wesenberg-Lund, 1959b p. 55; Edmonds, 1971 p. 140; Cutler, 1977 p. 139.

Location of type: Not known; specimen from New Britain.

Description: Specimen stout, cylindrical, narrowing slightly towards posterior and dark purple in colour in preserved condition. Body wall thick. Trunk 190 mm long and about 12-15 mm wide. Specimen contracted and longitudinal muscle bands not apparent externally. Prominent hemispherical papillae scattered on anterior eighth and posterior third of trunk, their diameter being 0·27-0·55 mm. Introvert, in retracted condition, about 45 mm long. Dissection of introvert shows presence of numerous rows of flat, circular papillae but no hooks.

Longitudinal muscles 17-18, with only slight anastomosation. Four short retractor muscles arise from two levels, a ventral pair from muscles 2-3 or 3-4 and a dorsal pair more anteriorly from bands 4-5. Oesophagus short but coiled intestine very long. Spindle muscle arising anteriorly from three roots, one being attached in front of anus, one to muscle 7 on right side and another to muscle 5 on the left near base of dorsal retractors. Spindle muscle fixed posteriorly. A fixing muscle connects posterior region of intestine to body wall. Wing muscle very strong. Gut filled with tightly packed coral fragments. Caecum not observed but rectal region damaged during dissection. Two nephridia, free for most of their length, arise at about same level as anus or just anterior to it. Contractile vessel with very numerous short villi, giving it a tufted appearance. No transverse dissepiments in body cavity. Brain not noticeable.

Systematics: This species can be distinguished from other Australian species of the same genus because (1) it lacks transverse body dissepiments, (2) it lacks hooks, and (3) it has less (17-18) longitudinal muscles than *S. boholense* which possesses about 30.

Previous Australian record: Coral Sea (30° 05'S, 154° 33'E) at 1 560 m (3) (Cutler, 1977 p. 139).

Distribution: (1) in Australia: Queensland (Heron Is.); Coral Sea (at 1 560 m).

(2) elsewhere: New Britain; Guam; Mauritius.

Specimens examined and locality: Queensland—Heron Is., (1) SAM E1125.

Siphonosoma (Siphonosoma) rotumanum (Shipley)

(Fig. 30)

Sipunculus rotumanus Shipley, 1898 pp. 469-470, pl. 37, figs 1-3.

Siphonosoma hawaiense Edmonds, 1966 pp. 386-388, figs 1-4.

Siphonosoma rotumanum: Edmonds, 1971 p. 143, fig 4; Stephen & Edmonds, 1972 p. 71.

Location of type: British Museum (Nat. Hist.), London; specimen from Rotuma.

Description: Specimen cylindrical and slightly curved ventrally. Trunk about 65-67 mm long and 8 mm wide. Introvert about 30 mm long, armed with transverse rings of pale-coloured, blunt hook-like structures. Although they seem larger than those described by Edmonds (1966, 1971), hooks closely resemble those of *S. rotumanum*. Papillae of two kinds; one, found mostly on introvert, is small, circular, about 0·1 mm in diameter, with a clear pore at its centre and the other, found mostly on trunk and few in numbers, is larger, hemispherical and about 0·4 mm in diameter. None of papillae black, as reported by Edmonds (1971).

Longitudinal muscles 15-16 and slightly anastomosing. Four retractors arise at different levels, a long ventral pair in mid-region of trunk from muscles 2-3 and a shorter dorsal pair more anteriorly from muscles 4-5; all fuse anteriorly. Alimentary canal held in position by fine fastening strands and a spindle muscle. Spindle muscle attached anteriorly well in front of anus and posteriorly by several radial-like extensions. Spindle muscle with two very prominent lateral roots connecting with muscle 7 on each side of nerve cord. Additional fastener runs from muscle 1 (at a point mid-way between base of dorsal and ventral retractors) to penultimate spiral of intestine. Wing muscle strong. Rectal caecum present. Nephridia slender, fixed to muscle 2 for most of their length and opening at about same level as anus; nephrostomes prominent and crescentic. Tufted bodies present on body wall near nephrostomes.

Systematic position: The specimen corresponds closely with specimens of *S. rotumanum* in my possession from Rotuma, Hawaii and Guam. The "hooks" or adhesive structures on the introvert are a little larger than those previously described and only one fastener was found arising between the dorsal and ventral retractors.

Much of the internal anatomy of *S. rotumanum* is like that of *S. australe* (Keferstein). The hooks of the latter, however, are sharp. *S. rotumanum* differs from *S. novaepommeraniae* (Fischer, 1926) in the possession of hooks.

Previous Australian record: Low Is., Queensland (Gibbs, 1978).

Distribution: (1) In Australia: Queensland.

(2) elsewhere: Pacific Ocean at Rotuma, Hawaii, Solomon Is. and Guam.

Specimen examined: Queensland—Low Is. (1) SAM E1128.

Family Golfingiidae and key to genera

Golfingiidae Stephen & Edmonds, 1972 p. 77.

Description: Tentacles basically surround mouth and may be finger-like, thread-like, branched or dendritic; they may be reduced to a few lobes or even be absent. No coelomic extensions in body wall. Longitudinal and circular musculature continuous. Tentacles usually interrupted mid-dorsally by a nuchal organ. Type genus: *Golfingia* Lankester, 1885.

KEY TO GENERA OF *GOLFINGIIDAE*

1. One nephridium 2
   Two nephridia 3
2. Anus on anterior region of introvert near mouth. Single retractor muscle. Introvert very long . *Onchnesoma* (p. 32)
   Anus on trunk and not on introvert. One or two retractors. Animals usually inhabiting discarded shells of gastropods and scaphopods, sometimes the tubes of annelids and more rarely solitary corals ..... *Phascolion* (p. 29)
3. Tentacles arising from 4-8 stems and branching or dendritic. Retractors usually two, very rarely four. Contractile vessel with well-developed tubules or villi ..... *Themiste* (p. 32)
   Tentacles usually finger-or thread-like and not branching; sometimes reduced to a few lobes or more rarely absent. Retractor muscles two or four ..... *Golfingia* (p. 18)

Genus **Golfingia** Lankester

Golfingia Lankester, 1885 p. 469; Fisher, 1950b p. 548; 1952 pp. 388-9; Stephen and Edmonds, 1972 pp. 77-80; Cutler and Murina, 1977 pp. 173-187.

Description: Often bottle- or flask-shaped, sometimes cylindrical or sub-cylindrical. Longitudinal and circular musculature continuous. One or more rows of finger- or thread-like tentacles usually surround mouth; in few species tentacles much reduced or even absent. Nuchal organ usually present mid-dorsally in ring of tentacles. Hooks present or absent. One or two pairs of retractor muscles. Spindle muscle may or may not be attached posteriorly to body wall.

Type species: *Sipunculus vulgaris* de Blainville, 1827.

Remarks: The genus is large, containing more than 100 species. Only about six of these are present in collections in Australia; most of the species listed

in this paper are from the records of other workers. The genus has been divided into subgenera by Fisher (1950b), Wesenberg-Lund (1959a), Stephen (1964), Cutler and Murina (1977) and Murina (1967; 1975a; 1977). In dealing with the taxonomy of the genus I have largely followed Cutler and Murina (1977) who reviewed the group and synonymised a number of species. I received Murina's latest subdivision of the genus (Murina, 1977) only after the present paper had been typed.

KEY TO SUBGENERA OF *GOLFINGIA*

1. One pair of retractor muscles 2
   Two pairs of retractor muscles 4
2. Spindle muscle not attached posteriorly 3
   Spindle muscle attached posteriorly ..... *Siphonoides*†
3. Contractile vessel without villi ..... *Phascoloides* (p. 24)
   Contractile vessel with villi ..... *Thysanocardia* (p.27)
4. Nephridia bilobed ..... *Mitosiphon* (p. 22)
   Nephridia single-lobed 5
5. Spindle muscle attached posteriorly ..... *Golfingiella* (p. 27)
   Spindle muscle not attached posteriorly . *Golfingia* s.s. (p. 19)

Subgenus **Golfingia** s.s.

Golfingia sensu stricto Fisher, 1950b p. 549; 1952 p. 390; Stephen and Edmonds, 1972 p. 81; Cutler and Murina, 1977 p. 179.

Description: Two pairs of retractor muscles. Hooks may or may not be present. Contractile vessel simple and without villi. Spindle muscle not fixed posteriorly.

Type: *Sipunculus vulgaris* de Blainville.

KEY TO SPECIES OF SUBGENUS *GOLFINGIA* REPORTED FROM AUSTRALIA

1. No hooks or spines on introvert
   G. margaritacea adelaidensis (p. 21)
   Introvert with hooks or spines 2
2. Anterior and posterior extremities of trunk of unrelaxed specimens forming a cap or shield-like structure; globose papillae present on shield ..... *G. herdmani* (p. 19)
   No cap or shield-like structure at extremities of trunk 3
3. Spines tend to be straight; small swelling at base of spine
   G. vulgaris queenslandensis (p. 21)
   Spines claw-like; no swelling at base of spines *G. ohlini* (p. 22)

Golfingia (Golfingia) herdmani (Shipley)

(Figs. 32, 36-38)

Centrosiphon herdmani Shipley, 1903 pp. 171-174, pl. 1, figs. 4-10.

Location of type: not known by author; type locality, Sri Lanka (= Ceylon).

Description: Specimens light to dark brown in colour and cylindrical. When freshly collected or fixed without relaxation they usually assume the characteristic shape, anterior and posterior regions of trunk looking rather like aspidosiphonid caps or shields which are surrounded at their junction with trunk by a fold of body wall. Caps usually dark brown or rust coloured in contrast with light brown trunk. In relaxed specimens caps and folds less noticeable or may be difficult to discern, then resembling more closely a typical golfingiid. Caps covered with small, rather globose, glandular, dark rust-brown, slightly stalked papillae tending to lie on elevated, radial ridges of body wall which suggests that longitudinal musculature in these areas could lie in bundles. An examination of transverse sections of the area, however, shows that this is not so, and that the ridging is in layers external to the dermis. Nor do sections show hardened or cornified structures found in cap of some aspidosiphonids (Hyman 1959, fig. 219H).

Length of trunk of 20 unrelaxed specimens 25-65 mm, width 3-8 mm. Introvert about a quarter to half length of trunk, 2-3·5 mm wide and arising centrally from cap and not ventrally as in *Aspidosiphon*; anterior region slightly bulbous. Mouth surrounded by numerous finger-like tentacles. Anteriorly introvert armed with randomly arranged, light to dark brown hooks or spines 0·15-0·20 mm long. Associated with spines at or near their base is a small bulbous swelling of body wall which sometimes appears to lie between the wings of the spines. Papillae on introvert base and on anterior cap bulbose (with tendency to be stalked), dark brown and 0·12-0·19 mm in diameter. Papillae on trunk wall flatter, less pigmented, smaller and less noticeable. Trunk may feel and appear smooth although covered with small, white, glandular openings. On posterior cap papillae dark brown-rust coloured and about same size as those on anterior cap.

Four retractor muscles separate for most of their length; a strong ventral pair arising from about middle of trunk and a weaker dorsal pair more anteriorly. Oesophagus fastened for some of its length to ventral retractors by thin mesentries. Intestine long (about 20 double spirals). Rectal caecum present. Three fixing muscles, either two to oesophagus and one to rectum or one to oesophagus, one to posterior spiral and one to rectum. Wing muscle strong, sometimes extending almost to nerve cord on each side. Spindle muscle strong, arising under rectum either from a triangular flap of tissue, the apex of which connects with spindle muscle or (more frequently) from two strong roots (perhaps the lateral parts of the triangular flap). Spindle muscle not fixed posteriorly. Nephridia tubular but may be swollen near nephridiopore, arising just in front of anus, about a third as long as trunk and free for most of their length.

† No species of this subgenus has been reported from Australia.

FIG. 32. *Golfingia herdmani*, (specimens from Proper Bay, South Australia).

FIG. 33. *Golfingia margaritacea adelaidensis*, (specimen from Aldinga Bay, South Australia).

Gonads at base of ventral retractors. Contractile vessel tubular and without villi. Nuchal organ present but not always readily noticeable. Two eyespots.

Systematic position: The specimens fit well the description of *Centrosiphon herdmani* Shipley, 1903 described from two specimens from Sri Lanka (formerly Ceylon). No other record of the species exists. Shipley placed them in a new genus because they possessed, anteriorly and posteriorly, thickened, "chitinoid" shields and because the introvert arose from the centre of the shield and not ventrally to it as in *Aspidosiphon*. Transverse sections of the "shields", however, show that structurally they are not differentiated from the rest of the body wall and that no chitinous bodies are present. When the specimens are relaxed the "shields" usually become less evident and sometimes disappear. Because the presence of the shields or caps is an uncertain character it seems unwise to use it to separate off a new genus. The tentacles are arranged like those in *Golfingia*, the papillae, the introvert hooks and the internal anatomy of the specimens are golfingiid and not aspidosiphonid-like. At present, it seems better to me to call the species *Golfingia (Golfingia) herdmani* rather than *Centrosiphon herdmani*. The transference of the type of the genus *Centrosiphon* to *Golfingia* makes the genus *Centrosiphon* invalid. I have not been able to find Shipley's type; it is not deposited in either the Nat. Hist. Mus., London or the Museum of the Zool. Dept. of the University of Cambridge (U.K.), the places where most of his types were lodged.

For some time I was uncertain as to whether or not *G. herdmani* and *G. margaritacea adelaidensis* were conspecific. I have decided against this possibility because *G. margaritacea adelaidensis* lacks hooks (they are present in all my specimens of *G. herdmani*), its anterior and posterior trunk is not modified to look like shields and globose papillae are not present on its body wall.

The taxonomic position of the specimens, however, is still unsatisfactory. Species of *Golfingia* with shield-like structures at one or both extremities of the trunk have been previously described, *G. (Phascoloides) rutilofusca* (Fischer), redescribed by Murina (1967) and by Cutler (1977), being one. *Golfingia* sp. of Cutler (1977 p. 140) as shown in his fig. 2 is closely related to *G. herdmani* and matches some of my Australian specimens. Murina (1975a p. 1085) created *Dushana*, as a subgenus of *Golfingia* to contain *G. scutigera* and *G. adriatica* both of which she said, possessed shield-like modifications at the extremities of the trunk. *G. herdmani* might possibly fit in this subgenus. Both Cutler and Murina now appear to have doubts about the subgenus

because neither of them in their most recent reviews of the genus (Cutler & Murina 1977; Murina, 1977) mention *Dushana*. Murina (1977 p. 212) now places *G. scutigera* (Roule), the type of *Dushana*, in the subgenus *Golfingia* s.s. No previous Australian record.

Distribution: (1) in Australia: Proper Bay, near Port Lincoln, South Australia.

(2) elsewhere: Sri Lanka (Ceylon).

Specimens examined and localities: South Australia—Proper Bay (part of Port Lincoln at base of Eyre Peninsula); amongst roots of *Posidonia* about 25 m from base of low cliffs at point where railway line to Coffin Bay crosses road to Sleaford Bay. To find the animals it is necessary to dig up a square or sod of *Posidonia* and pull it apart. The animals are well camouflaged. (15) SAM E1149; (10) SAM E1158; (3) SAM E1143.

Golfingia (Golfingia) margaritacea adelaidensis Edmonds

(Figs. 33, 39)

Golfingia margaritacea adelaidensis Edmonds, 1956 pp. 302-3, pl. 2, fig. 2.

Location of type: Australian Museum, Sydney; specimen from Aldinga reef, St. Vincent Gulf, South Australia.

Description: Specimens long, slender, cylindrical and rather active when alive; yellow-brown and tending to glisten. Trunk 60-100 mm long, maximum width 4-7 mm. Posterior extremity usually tapering to a sharp point. Anterior and posterior extremities of trunk show no sign of ridging and no tendency to form caps as in *Golfingia herdmani*. Body surface bearing numerous small, rather flat papillae best developed and most thickly packed on anterior and posterior regions of trunk. They appear as white, circular to elliptical structures about 0·1-0·2 mm in diameter, in a yellow matrix of body wall. Introvert slender, comparatively short, 20-25 mm long, 2-3 mm wide and lacking hooks. Anterior extremity of introvert of living and dead specimens usually swollen into a bulb-like structure 3-6 mm in diameter. Tentacles short, digitiform, white and up to 80 in number. Body wall generally thin.

Two ventral retractors arise close to nerve cord in anterior third of trunk and two dorsal retractors more anteriorly near level of anus. Retractors separate for most of their length. Oesophagus fastened to ventral retractors by two mesenteries; intestine long, consisting in one specimen of 34 double spirals. Spindle muscle arising from a triangular flap of tissue beneath a strong wing muscle and not fastened posteriorly. Fastening muscles three or four. One (F1) arises from body wall just below left dorsal retractor and connects with oesophagus. A second (F2), arising near origin of F1, connects with last spiral of intestine (and in a few specimens gives off a short branch to posterior oesophagus). In two specimens F1 and F2 arise from same point. F3 (when present) and F4 arise between right dorsal and ventral retractors and connect with the last and penultimate intestinal whorls.

These specimens differ from *Golfingia herdmani* (Shipley) from Proper Bay because (1) they do not form a cap or ridge at the extremities of the trunk (2) they lack introvert spines and (3) they lack rusty coloured, globose papillae on the anterior and posterior surfaces of the trunk and the ridges on which they lie, both of which are present in *G. herdmani*.

Edmonds (1956 p. 303) says that "a caecum is lacking or possibly rudimentary". Recent study of more specimens shows that a small caecum is usually present. The specimens are close anatomically to *G. margaritacea* (Sars), described from Norway and reported widely from the northern hemisphere and from the Antarctic and sub-Antarctic. Recently Cutler (1977 p. 139) has reported *G. margaritacea* from off the South Australian coast. Whether his specimen is the same as mine I do not know. Murina (1977 p. 230) has placed *G. margaritacea adelaidensis* in the synonymy of *G. margaritacea margaritacea*. I find it difficult, however, to lump the South Australian material with that described by Théel and Wesenberg-Lund from Norway and Greenland and that from Alaska described by Fisher (1952). The spindle muscle of my specimens is strong and arises from a triangular flap of tissue under and separate from the wing muscle and not from the rectum as shown in pl. 23 fig. 3 of Fisher (1952). Théel's fig. 174 shows only two fixing muscles (there are three or four in mine) and no stout fixing muscle runs to the rectum near the anus, as shown in Théel (1905) fig. 174. In addition the specimens are always yellowish-brown in colour.

Previous Australian records: Edmonds (1956).

Distribution: Known only from Aldinga, South Australia.

Specimens examined and locality: In sand and debris amongst the roots of the marine angiosperm *Amphibolis antarctica* on the reef at Aldinga Bay, St. Vincent Gulf, South Australia. (1) SAM E1159, (2) SAM E1148, (1) SAM E1176, (1) SAM E1177, (1) AMS W3603.

Golfingia (Golfingia) vulgaris queenslandensis Edmonds

Golfingia vulgaris queenslandensis Edmonds, 1956 pp. 303-4, pl. 17.

Location of type: Australian Museum, Sydney; specimens from Heron Is., Queensland.

Remarks: No additional specimens have been collected since Edmonds' 1956 record. There is still doubt about the identity of these specimens. They possess two pairs of retractors, hooks, three fastening muscles and a spindle muscle not attached posteriorly. The introvert is swollen anteriorly and there is a weakly developed rim between the base of the introvert and the trunk, much like that found in *Golfingia herdmani*. The hooks, however, are different from those of the latter species.

Distributions: Known only from Queensland.

Specimens examined: (2) Heron Is., Queensland, AMS W3602.

*Golfingia (Golfingia) ohlini (Théel)

Phascolosoma ohlini Théel, 1911 p. 29, pl. 2, figs 21-23, pl. 3, figs 24-27, pl. 5, figs 69-70.

Golfingia ohlini: Fisher, 1950b p. 550.

Location of type: Not known; type locality South Georgia.

Description: I have not seen Australian specimens of the species. Théel's account of the type specimen reads, "Total length of body 16 or 17 mm. Body elongate, subcylindrical, with posterior extremity pointed. Tentacles slender, 16 in number, arranged in groups on each side of the median line. Distinct ciliated sense pads present, separating the dorsal tentacles. Skin whitish, shining with small cylindrical papillae, crowded at the posterior extremity of the body and scarce at its middle. Behind the tentacles mamillary wart-like papillae and scattered hooks, both directed backwardly. Two free segmental organs. Muscular layers of the body-wall continuous, not separated into bands. Two ventral and two dorsal retractors. Intestinal spiral composed of about 14 double turns and not attached posteriorly."

Australian record: New South Wales, off Broken Bay (33° 34'5 S, 152° 06'5 E) (1) Murina, 1972 pp. 301-302.

Distribution: (1) in Australia: off coast of New South Wales.

(2) elsewhere: Antartica and sub-Antartica; Mauritius and South Africa; Chile.

Subgenus **Mitosiphon** Fisher

Mitosiphon Fisher 1950b p. 550; 1952 p. 393; Stephen & Edmonds 1972 p. 113; Cutler & Murina 1977 p. 180.

Description: Two pairs of retractor muscles. Introvert hooks (if present) have accessory comb of spinelets at base. Nephridia bilobed. Spindle muscle not attached posteriorly.

Type *Phascolosoma hesperum* Chamberlin.

KEY TO SPECIES OF SUBGENUS *MITOSOPHON* REPORTED FROM AUSTRALIA

1. Introvert hooks with 4-5 accessory teeth ..... *G. misakiana* (p. 22)
   Introvert without hooks ..... *G. trichocephala* (p. 23)

(Murina, 1977 has now assigned *G. trichocephala* to a subgenus *Apionosoma* Sluiter, 1902; *G. misakiana* has been left in *Mitosiphon).*

Golfingia (Mitosiphon) misakiana (Ikeda)

Phascolosoma misakianum Ikeda, 1904 pp. 7-9, pl. 1, fig. 3, pl. 3, figs 30 -33; Fischer, 1919a p. 281; 1927 p. 204.

Golfingia misakiana: Fisher, 1952 p. 393; Cutler, 1973 p. 144; Murina, 1970 p. 66; 1977 p. 236.

Location of type: Not known to author; specimen from coast of Misaki Bay, Japan.

Description: Four specimens, two in very good condition and with introvert extended, were examined. Specimens small and slender and introvert almost thread-like. Trunk of largest 11 mm x 1·5-1·8 mm and introvert about 40 mm x 0·4-0·7 mm. Body wall thin and transparent enough to show most of internal anatomy without dissection. Mouth surrounded by 5 (?6) swellings or protuberances, probably corresponding to tentacles. About 20 complete rows of clear, almost transparent hooks surround anterior region of introvert. Rows then become incomplete and ultimately hooks sparsely scattered. Hooks small, 0·022-0·027 mm tall, with sharply bent tips and with usually five sharp accessory teeth near base. More posteriorly placed hooks smaller and may lack accessory teeth. Introvert bearing very numerous, small urn-shaped glandular papillae. Posterior trunk papillae about 0·20-0·25 mm in diameter and rather flat, consisting of a few rounded plates arranged like the petals of a flower. In mid-trunk, papillae are larger (up to 0·1 mm in diameter) and the arrangement of plates less definite. One feature of specimens is that both trunk and introvert are covered by a very great number of very small "points" (possibly glandular pores), placed very closely to each other, lying in both longitudinal and transverse rows and making the surface appear striated.

The most transparent specimen shows four retractor muscles, two long, bilobed nephridia and a posteriorly fastened spindle muscle.

Systematic position: The specimens are considered to be *G. misakiana* (Ikeda). The question

arises whether *G. misakiana* and *G. trichocephala* (Sluiter), which is also being recorded in this paper from the eastern coast of Australia, are the same species, a species with a genetically determined set of hooks which for some reason concerned with the animals's environment may either be lost or never appear. Cutler (1973 pp. 139-144) discusses the question. He states that his specimens of *G. trichocephala* and apparently the type specimen (since he examined it) lack hooks. Murina (1970; 1977) describes *G. trichocephala* as being hookless. Neither can I find hooks on some specimens from Moreton Bay, Queensland which I have called *G. trichocephala* nor on some from Madagascar, sent to me by Dr. Thomassin. Murina must consider the two species valid because she described both of them in her 1977 paper and I think it best to regard them so, at present. If the two are the same it is remarkable that specimens with and without hooks have not been found together in the same collection. Nevertheless many characters of my specimens of *G. misakiana* correspond with those of *G. trichocephala* e.g., size and shape, anterior region of introvert and papillae (Murina, 1977, fig. 162), bilobed nephridia, four retractor muscles and even the fine striations on the surface of the trunk and introvert, which are present in both my specimens of the two species. The figures of the species were drawn from the specimen SAM E1161. The specimens lack the large papillae on the posterior surface of the trunk, present in *G. murinae* Cutler, 1969.

Previous Australian record: Western Australia (Fischer, 1919a).

Distribution: (1) in Australia: Western Australia at Shark Bay, 6-9 m (Fischer 1919a); N.S.W. at Broughton Is.

(2) elsewhere: Japan; New Guinea, Tanzania and Easter Is. (Murina 1977 p. 238).

Specimens examined and localities: N.S.W. at Broughton I., amongst roots of marine angiosperm *Posidonia* (Collet and Pat Hutchings) (2) AMS W13157, (1) AMS W12991, (1) SAM E1161.

Golfingia (Mitosiphon) trichocephala (Sluiter)

(Figs. 34, 40)

Apionsoma trichocephalum Sluiter, 1902 pp. 42-44, pl. 4, figs. 8-11; Murina, 1977 p. 236.

Golfingia trichocephala Murina, 1972 p. 303; Cutler, 1973 p. 139; Cutler and Murina, 1977 p. 180.

Location of type: Zoological Museum, Amsterdam; specimen from near Surabaya, Java, Indonesia.

Description: Small, white-brown, slender species with a long, almost thread-like introvert. Trunk 3·0-5·1 mm long, maximum width usually less than 1 mm; curved ventrally in most specimens. Posterior extremity pointed. Body wall thin and internal structures often visible under strong light. Introvert 45 mm long in specimen with trunk 4·1 mm long; lacking hooks and tentacles.

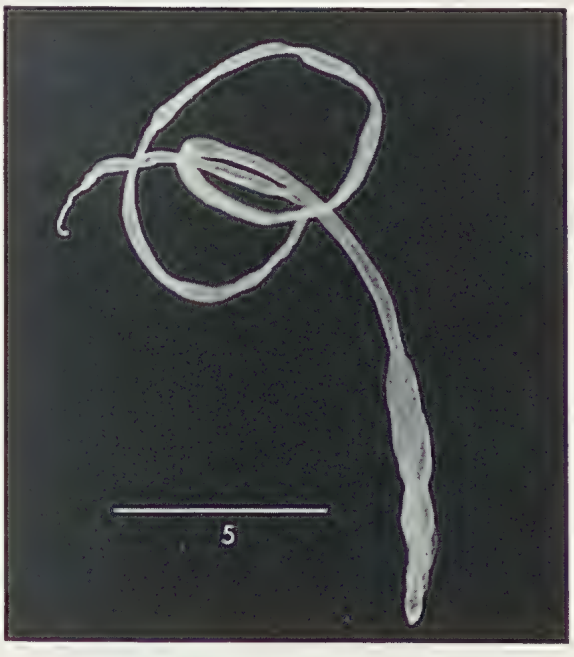


FIG. 34. *Golfingia trichocephala,* (specimen from Moreton Bay, Queensland). Scale measurements are in mm.

Longitudinal musculature continuous. Four slender retractor muscles, a ventral pair arising very close to nerve cord in middle of trunk and a dorsal pair more anteriorly. Intestine long, coiled and slender. No rectal caecum observed in 2 dissected specimens. Spindle muscle fixed posteriorly to body wall. Rectum attached to body wall near anus by a strand of tissue. Suspension at this point accounts for what Culter (1973) described as a "genuflection in the rectum". Contractile vessel inconspicuous. Two yellow-brown, free, bilobed nephridia of equal length opening anteriorly to anal aperture.

Systematic position: *Apiosoma trichocephalum* Sluiter, 1902 was dredged at 56 m from Indonesia (lat. 7° 25′ S, long. 113° 16′E) and described as possessing nephridia with single lobes. Cutler (1973 p. 138) re-examined Sluiter's type and found that the nephridia were bilobed. After a careful study of the type specimens he concluded that *G. tenuissima* Wesenberg-Lund, 1959a and *G. longirostris* Wesenberg-Lund 1959a were junior synonyms of *G. trichocephala*. Murina (1977 p. 180) removed it from the subgenus *Mitosiphon* and placed it in *Apiosoma* which she now regards as a subgenus.

Fischer (1919a) reported *Golfingia misakiana* (Ikeda) from Shark Bay, Western Australia. *G. misakiana* and *G. trichocephala* are alike in many respects. The former, however, is described as

possessing introvert hooks with accessory teeth. The specimens in the present collection from Rottnest Is., like those from Queensland, lack hooks.

G. trichocephala is identified by its small size, a very long slender introvert lacking hooks and tentacles, the presence of four retractors and two bilobed nephridia.

Previous Australian record: off coast of New South Wales (33° 34′ S, 152° 16′ E) by Murina (1972).

Distribution: (1) in Australia: Queensland, New South Wales and Western Australia.

(2) elsewhere: South Africa and West Africa (Wesenberg-Lund, 1959a, 1959b, 1963); Western Atlantic (Cutler, 1973); Indonesia (Sluiter, 1902); Coral Sea and Tasman Sea (Cutler, 1977); Gulf of Aden (Murina, 1970).

Specimens examined and localities: Queensland —Moreton Bay (8), dredged by S. Cook (Dept. of Zoology, Univ. of Queensland), SAM E1152; same locality (5) coll. W. Green (Univ. of Queensland) SAM E1150 and SAM E1154. Western Australia—William Bay, Rottnest Is. (2) AMS W10565.

Subgenus **Phascoloides** Fisher

Phascoloides Fisher 1950b p. 550; 1952 p. 395; Stephen and Edmonds, 1972 p. 131; Cutler and Murina 1977 p. 182; Murina, 1977 p. 180.

Description: One pair of retractor muscles. Introvert with or without hooks. Contractile vessel simple and without villi. Spindle muscle, if present, not attached posteriorly.

Type: *Sipunculus eremitus* Sars, 1851.

(Murina 1977 p. 180 has replaced *Phascoloides* Fisher, 1950b by *Nephasoma* Pergament 1946 on the grounds of priority. Her argument is that since *Nephasoma marinki* Pergament, 1946 = *Golfingia glacialis* Danielssen and Koren, 1881 and because Fisher (1950b) placed *G. glacialis* in his subgenus *Phascoloides* the term *Nephasoma* is an older name in the group).

KEY TO SPECIES OF *PHASCOLOIDES* RECORDED FROM AUSTRALIA

1. Tentacles absent or reduced to leaf-like structures or lobular projections ..... **G. minuta* (p. 24)
   ..... **G. improvisa* (p. 24)
   Tentacles numerous and finger-like 2
2. Wing muscle well developed and spindle muscle arising from two strong roots ..... *G. schuettei* (p. 25)
   Wing muscle not well developed and spindle muscle not arising from two strong roots ..... **G. pellucida* (p. 26)

*Golfingia (Phascoloides) improvisa (Théel)

Phascolosoma improvisum Théel, 1905 pp. 82-83, pl. 5, figs. 51-58; pl. 12, figs. 177-182, pl. 14, figs. 202-3.

Golfingia improvisa Murina, 1958 pp. 1625-1628; Stephen and Edmonds, 1972 p. 145; Cutler, 1973 p. 155; Murina,1977 pp.184-6, figs.122a-e.

Location of type: Not known to author; type locality, West coast of Sweden.

Description: Théel's account reads, "Total length of largest specimen 15 mm. Proboscis about half of the total length, or shorter. Trunk cylindrical, slightly tapering anteriorly and behind. Tentacles absent and replaced by some irregular, rounded prominences on the oral disc. Skin hyaline and provided with distinct papillae especially on the posterior end of the trunk and on the proboscis. A girdle of hooks always present. Two ventral retractors embracing the nerve cord with their roots, and varying greatly in length. They are attached to the body-wall either at the middle of the trunk, or at its anterior part or else considerably posteriorly. Two free segmental organs. Intestinal spiral composed of about 13 or more double turns and not attached posteriorly. Body cavity never contains eggs."

Remarks: This species has also been reported from New Zealand in the tube of a foraminiferan (Edmonds, 1976). *G. improvisa* is closely related to *G. minuta* (Keferstein) and thought to be synonymous with it by some workers (see under *G. minuta*). Murina (1977 pp. 184-8) discusses the question.

Australian record: Tasman Sea (39° 35′ S, 153′ 45′ E) "in shell of a foraminiferan" (Murina, 1972 pp. 300) at 3 970 m.

Distribution: (1) in Australia: Tasman Sea.

(2) elsewhere: Sweden, Greenland, east coast of New Jersey, U.S.A., France, British Isles, north-west Pacific, South Africa.

* Golfingia (Phascoloides) minuta (Keferstein)

Phascolosoma minutum Keferstein, 1863: p. 40, pl. 3, figs 7-10; Théel, 1911 p. 32, pl. 3, figs 42-45, pl. 4, figs 46-49.

Golfingia minuta: Murina, 1957a pp. 994-995; 1958 pp. 1628-1634; 1977 pp. 186-188, fig. 123; Cutler, 1973 pp. 155-159.

Location of type: Not known to author; specimen from St. Vaast la Houge, Normandy, France.

Description: A small species. According to Keferstein trunk about 6 mm long and introvert 8

mm. Tentacles reduced to two leaf-like structures or 4-6 "lobular projections" (Cutler, 1973 p. 158). Musculature thin and continuous. Four retractors arising in posterior third of trunk (Cutler says "a wide variety of locations"). Spindle muscle not fixed posteriorly. Nephridia short, sac-like, free and opening a little behind anus. Small caecum usually present according to Cutler. Akesson (1958) says that *G. minuta* is hermaphroditic.

Systematics: *G. minuta* is very closely related to *G. improvisa*. Cutler (1973 p. 158) thinks that they are synonymous but Murina (1958 p. 1624; 1977 p. 186) considers them different.

Australian record: New South Wales, off Broken Bay (33° 34'5 S, 152° 06'5 E) (5) Murina, 1972 p. 300.

Distribution: (1) in Australia: off coast of New South Wales.

(2) elsewhere: Artic Sea, North Sea, western-north Atlantic, Mediterranean, off South Africa, north-west Pacific, Chile, and Falkland Is.

***Golfingia (Phascoloides) pellucida** (Keferstein)

Phascolosoma pellucidum Keferstein, 1865 p. 433, pl. 32, figs 26-27; Fischer, 1919a p. 281.

Golfingia pellucida: Fischer, 1950b p. 550; Cutler, 1973 pp. 159-162.

Location of type: Not known by author; specimen from St. Thomas, Antilles, West Indies.

Description: According to Keferstein the body is 8-9 times as long as wide, and the introvert is a half to three quarters as long as the body. Skin thin and transparent, often iridescent, with uniformly distributed small, wart-like papillae which posteriorly are pointed and yellow. Hooks few and irregularly distributed between the papillae and folds of skin on the anterior part of the introvert; they are seen only with the aid of a microscope and are 0·032 mm high and 0·044 mm long. Tentacles numerous and rather long.

Musculature thin, continuous and without banding. Two retractors arising in the middle third of the trunk. Two large eyespots. Intestine of about 14 spirals, without a posteriorly fastened spindle muscle. Three fasteners to the first spiral. Rectum short. Contractile vessel not observed. Nephridia short and free. Length of body 32-45 mm, of introvert 15-23.

Several specimens from St. Thomas, in coral at depth of 2 feet.

Remarks: Judging from the records of Keferstein (1865), Selenka & de Man (1883 p. 32), Augener (1903 p. 299), Fischer (1914 p. 8), Cutler (1973 p. 159) and Murina (1968 p. 421; 1977 p. 196), *G. pellucida* is a variable species. Fischer (1919 ap. 281) reported it from Cockburn Sound, Western Australia. Unfortunately he gave no information about the specimens. Recently I have examined two other specimens from Cockburn Sound and have decided that, although closely related to *G. pellucida*, they are different from it. I have referred them to *G. schuettei* (Augener, 1903), a species described from Sydney, New South Wales. Whether *G. schuettei* and *G. pellucida* are synonymous I am not able to say.

Australian records: Cockburn Sound, W.A. (Fischer, 1919a); Torres St., Q. (Selenka & de Man, 1883).

Distribution: Antilles, Costa Rica, Jamaica, eastern coast of South America, Amboina, western North Atlantic, Philippines, Singapore, Torres St., Gulf of Mexico, Gulf of Siam.

Golfingia (Phascoloides) schuettei (Augener)

(Figs. 35, 44-45)

Phascolosoma schuttei Augener, 1903 pp. 335-337, figs 17-18.

Golfingia schuettei: Murina, 1964a p. 238, fig. 12; 1971: 43; 1973: 16; 1974 p. 235; 1977 pp. 191-2, fig. 128; Stephen & Edmonds 1972 p. 156, figs 18a and b.

Location of type: Not known; specimen from Sydney, Australia (coll. by Dr. Schutte in 1876).

Description: Specimens light to golden brown or grey, usually long and sub-cylindrical. Trunk 33-160 mm long (three are longer than 100 mm) and 5-10 mm wide. Introvert usually not well differentiated from trunk, 10-25 mm long. Mouth surrounded by numerous digitiform tentacles which are made to look complexly arranged by radially projecting extensions of the tissue from which the tentacles arise, much as is shown in figs. 191-3 of Théel (1905). Zone of brown to black, sharply pointed hooks, lies posterior to tentacles. Hooks either straight or curved slightly at tip and varying in size and direction. Anterior hooks usually largest, projecting almost at right angles to surface; posterior ones smaller, often just piercing surface. Small papilla-like swellings usually present near base of each hook. Field of hooks may be better developed on ventral surface and in one specimen whole field much reduced.

FIG. 35. *Golfingia schuettei*, (specimen from Port Jackson, New South Wales).

Trunk papillae may be plumply conical, globose or short and cylindrical, the first two sometimes arising from a narrowed base or stalk. Musculature of body wall continuous. Two strong retractors, separate for part or most of their length, arise in middle or posterior half of trunk. Contractile vessel prominent but without villi. Wing muscle strong. Spindle muscle arises anteriorly from two strong roots attached to body wall on each side of just anterior to anus. Roots, separate from wing muscle, run under rectum and join near caecum to form spindle muscle (much as in *G. margaritacea adelaidensis* and *G. herdmani*). Spindle muscle free posteriorly. Three to five fastening muscles. F1, arising on left side of nerve cord runs to posterior oesophagus; F2, F3 and F4 (if present) connect with penultimate intestinal spiral and F5 with rectum. Nephridia two, usually tubular (sometimes swollen anteriorly), long free and opening at about same level as anus. Brain simple with two eyespots. Gonads at base of retractors. Twenty to thirty double intestinal spirals.

Systematic position: I am naming the specimens as *G. schuettei* (Augener) with some reservations, chiefly because I have not been able to compare them with the type specimen.

It is possible that the specimens, especially those from Cockburn Sound, W.A., are the same species as those from Cockburn Sound which Fischer (1919 p. 281) called *G. pellucida* (Keferstein, 1865). The type locality of the latter species is in the Antilles but Fischer (1919 p. 281) says that it is "circummundane". Unfortunately Fischer gave no information about his specimens. *G. pellucida* (especially long specimens) have been reported from Indonesia, Malaysia and the Philippines several times, (1) by Selenka & de Man (1883) from the Philippines, Singapore (specimens with trunk 80 mm long, introvert 45 mm and without hooks) and Torres St. (hooks lacking) and (2) by Augener (1903) from Amboina (specimens 70 mm long). Selenka says that he was not able to find any real difference between specimens from the Antilles and Rio de Janeiro and from the Philippines etc. and gave all them all the same name.

After comparison with specimens of *G. pellucida* from the Western North Atlantic, which were named and sent to me by Prof. E. Cutler, and some from Curaçao, collected by C. J. van der Horst (Zool. Mus., Amsterdam) I am inclined to think that the Australian specimens are different. They are much larger, cylindrical rather than flask shaped, their tentacles are more complexly arranged, their wing muscle is strong and the spindle muscle arises either from a triangular flap or two strong roots. Concerning size, Cutler (1973 p. 159) found that the trunk of 834 specimens of *G. pellucida* from the Western North Atlantic was 3-25 mm long and 1-3 mm wide (most were 6-10 mm long). Murina (1968 p. 422; 1972 p. 302; 1977 p. 192) also reports small specimens. For these reasons I am reluctant to lump my specimens with those from Curaçao and the North Atlantic. A translation of Keferstein's description of *G. pellucida* is given in this paper (see p. 25).

Phascolosoma schuettei Augener, 1903 was described from a single specimen collected at "Sydney" by Dr. Schütte in 1876. Augener says that that the specimen was with some others obtained from the Göttingen Museum. The type however, is not in the Museum today and there is no record that it was ever lodged there. The length of the trunk is about 70 mm and Augener figures its club-like papillae and its introvert hooks. Its tentacular crown consists of numerous, long, yellowish tentacles which surround the mouth in a single row. The single-rowed nature of the arrangement is obscured by the radially projecting folds of the tissue from which the tentacles arise (="Tentakelgrundes") much as it is in *Siphonosoma cumanense*. The species possesses two retractors which arise in the posterior two-thirds of the trunk, three fasteners, 63 intestinal spirals, a caecum and a spindle muscle not attached posteriorly. There is no doubt that my Australian

specimen and Augener's description closely correspond and it is unfortunate that the type specimen cannot be found for a comparison. The main difference seems to be in the number of fasteners. Murina (1964a p. 238) records two specimens from the Tasman Sea (37° 31'S, 163° 59'E) at 1330 mm and one from the N-W Pacific at 5397 m and in Murina (1973 pp. 69-70) several from the Peruvian-Chilean Trench at depths of up to 7 000 m. The specimens in my collection, however, were collected from shallow water, two from Port Jackson (= Sydney Harbor).

The trunk of *G. (Phascoloides) novaezealandiae* (Benham, 1904) may be long (up to 310 mm) and is sub-cylindrical; the species seems closely allied to *G. schuettei*. The four specimens so far described however, all lack introvert hooks. Sluiter (1902 p. 35) considered that his *G. subhamata*, dredged from two different localities in Indonesia, although closely related to *G. pellucida* was different from it. Recently I re-examined one of Sluiter's original specimens, a small one which I found difficult to work with. Whether *G. subhamata* and *G. schuettei* are the same I am unable to say.

G. schuettei differs from the other large Australian golfingiids *(G. margaritacea adelaidensis* and *G. herdmani)* in that it has only two retractors, while they have four.

Previous Australian records: New South Wales (Augener, 1903); Tasman Sea (Murina, 1964a).

Distribution: (1) in Australia: Port Jackson (N.S.W.); Cockburn Sound, Port Gregory and Dampier Archipelago (W.A.); Tasman Sea.

(2) elsewhere: N.W. Pacific Ocean; Peruvian-Chilean Trench.

Specimens examined: New South Wales—Port Jackson (1) AMS W3019 "under rocks" and (1) SAM E1171 (coll. P. Hutchings). Western Australia—Cockburn Sound (north of Jervoise Groyne) SAM 141/76; Cockatoo Is. (1) "under stones at low tide" WAM 149/76; Dampier Archipelago (1) coll. of WAM.

Subgenus **Golfingiella** Stephen

Golfingiella Stephen, 1964 p. 459; Stephen & Edmonds, 1972 p. 118; Cutler & Murina, 1977 p. 180; Murina, 1977 p. 240.

Description: Introvert without hooks but with tentacles or tentacular lobes. Two pairs of retractor muscles. Spindle muscle attached posteriorly. Nephridia single-lobed.

Type species: *Phascolosoma procerum* Möbius.

Remarks: I am following the lead of Cutler (1977 p. 141) in placing *G. murinae murinae* in this subgenus. Cutler (1969 p. 214), however, says that a few rows of transparent hooks are present on the introvert. It is difficult, therefore, to see how the species falls in *Golfingiella*. Murina (1977 p. 238), with some justification, has placed *G. murinae* in Mitosiphon. Perhaps the status of *G. murinae murinae* (= *unilobatae)* and *G. murinae bilobatae* needs investigation. Cutler and Murina (1977 p. 181) claim that, because its mouth lies outside the ring of tentacles, the species should be transferred to *Fisherana* (Phascolosomatidae).

*Golfingia (Golfingiella) murinae murinae Cutler

Golfingia murinae murinae Cutler 1969 p. 214 (as amended by Cutler); 1973 p. 145; 1977 p. 141-2, figs 4 and 5; Cutler and Murina, 1977 p. 181.

Location of type: U.S.N.M. no. 38247; type locality, 37° 13'N, 68° 40'W, dredged at 4 540 m.

Description: Trunk 1·5-13 mm long. Introvert four to six times length of trunk, with few rows of transparent hooks (some of which have an accessory comb of spinelets at base). Large mammiform papillae at posterior end of trunk. Four retractors arising from posterior third of trunk. Nephridia free and sac-shaped. Anus posterior to nephridiopores.

Australian record: Cutler, 1977 p. 142.

Distribution: (1) in Australia: Tasman Sea (off Port Macquarie, N.S.W.) (31° 27'S, 153° 33'E) dredged at 4 530 m (6) (Cutler, 1977 p. 142).

(2) elsewhere: "A deep water species (1 000-4 750 m) in the north-western Atlantic and in the north-western Pacific Ocean (3 950 m)" according to Cutler, 1977; off Kenya (3 950 m), east of Seychelles (3 300 m), N-W Philippine Trench (1 000 m), Sunda Trench (2 810-2 990 m), south of Bali (780 m). All these records from Cutler, 1977.

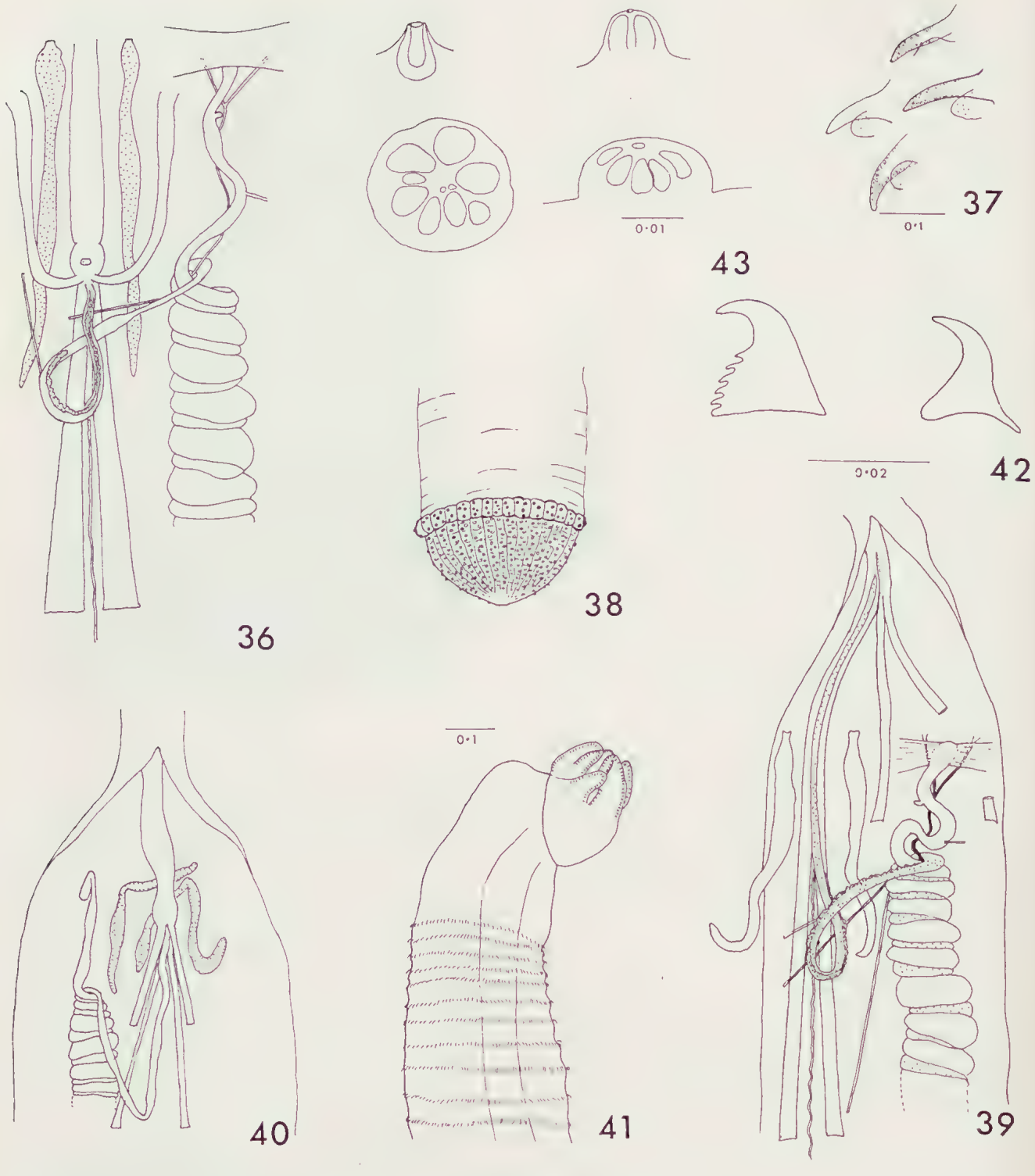
Subgenus **Thysanocardia** Fisher

Thysanocardia Fisher, 1950b p. 551; 1952 p. 400; Stephen & Edmonds, 1972 p. 120; Cutler & Murina, 1977 p. 181; Murina, 1977 p. 198.

Description: One pair of retractor muscles. Contractile vessel with branched or unbranched tubules. Nephridiopore usually opens in front of anus. No introvert hooks.

Type species: *Phascolosoma procerum* Móbius, 1875.

Remarks: The position of *G. coriaca* (Keferstein) in this subgenus is very uncertain because it possesses introvert hooks. Fisher (1950 p. 551; 1952 p. 395) placed it in the subgenus *Golfingia* s.s.



FIGS. 36-43. Figs. 36-38, *Golfingia herdmani;* 36, anterior region dissected; 37, introvert hooks; 38, posterior region of trunk. Fig. 39, *Golfingia margaritacea adelaidensis;* anterior region dissected. Fig. 40, *Golfingia misakiana;* 41, anterior region of introvert; 42, introvert hooks; 43, papillae from trunk.

Keferstein's fig. 23 and his description "Contractiler Schlauch . . . , mit mehreren sehr langen, cylindrischen Aussackungen" indicates that long tubules are present. In which case the position of the species in *Golfingia* s.s. is also uncertain.

Specimens of neither of the two species reported from Australia have seen by me. *G. coriacea* possesses hooks, *G. semperi* does not.

***Golfingia (Thysanocardia) coriacea** (Keferstein)

Phascolosoma coriaceum Keferstein, 1865 pp. 432-3, pl. 32, figs. 23-4; Selenka and de Man, 1883 pp. 34-5, pl. 2, fig. 15, pl. 5, figs. 50-53.

Golfingia coriacea Fisher, 1950b p. 551; Cutler, 1973 pp. 160-161; Cutler and Murina, 1977 p. 181.

Location of type: not known specimen from St. Thomas, West Indies.

Remarks: Murina's single specimen from South Australia is small, cream and pyriform. Trunk 7 mm long and 5 mm wide and introvert 3 mm long and 1·5 mm wide. Introvert hooks 0·1 mm long. Two retractor muscles present and "fluffy" polian vesicles.

No specimens of this species are in the collection of the South Australian Museum. The only ones from St. Vincent Gulf in the Museum which are small, possess two retractors, fluffy polian vesicles and introvert hooks are those of *Themiste fusca* (see p. 40). The latter is common.

Cutler (1973 p. 159) places *G. coriacea* in the synonymy of *G. pellucida* (Keferstein) on the grounds that Keferstein's specimen must have been aberrant.

Australian record: South Australia, near Adelaide (Murina, 1972 p. 298).

***Golfingia (Thysanocardia) semperi** (Selenka and de Man)

Phascolosoma semperi Selenka and de Man, 1883 pp. 37-38, pl. 5, figs. 56-59.

Golfingia semperi Fisher, 1950b p. 551.

Location of type: ?; specimen from Uhoy, Philippines.

Description: Trunk 28 mm long and slim. Two stout retractors. Tentacles filamentous but hooks lacking. Contractile vessel with numerous tubules. Nephridia about half as long as trunk, free and opening anterior to anus. Spindle muscle not fixed posteriorly.

Remarks: No specimens seen by the author. Although it has been reported several times the species seems not to have been re-described. Fisher's 1921 account takes up only three lines. Australian record: Cape Jaubert, Western Australia (Fischer, 1921).

Distribution: (1) in Australia: Western Australia.

(2) elsewhere: Philippines, Red Sea, Zanzibar and Fernando Po.

Genus **Phascolion** Théel

Phascolion Théel, 1875 p. 13; Stephen and Edmonds, 1972 pp. 164-165.

Description: Specimens usually small, living in empty shells of gastropods or scaphopods, in tubes of annelids, in burrows in coral rock or in solitary corals. Body usually spirally twisted and internal organs asymmetrically arranged. Only one, usually the right, nephridium present. Usually only one gonad. Musculature of body wall continuous. Characteristic adhesive or holding papillae usually present on surface of trunk.

Type species: *Phascolion strombi* (Montagu, 1804).

KEY TO AUSTRALIAN SPECIES OF *PHASCOLION*

1. Retractor single for all or most of its length 2
   Retractors double for all or most of their length 3
2. Retractor divided posteriorly near point of fixation into 3 short roots; caecum placed at a considerable distance from anus (half-third of way from anterior end of trunk) **P. pacificum* (p. 32)
   Retractor not divided posteriorly; caecum not reported *P. collare* (p. 29)
3. Some papillae on anterior surface of trunk near base of introvert with 2-4 points ..... *P. cronullae* n.s.p. (p. 30)
   Papillae on trunk with single points.. **P. dentalicolum* (p. 32)

Phascolion collare Selenka and de Man

(Fig. 52)

Phascolion collare Selenka and de Man, 1883 pp. 45-46, pl. 6, figs. 71-74; Fischer, 1922 p. 12; Cutler, 1977 pp. 144-5.

Type locality: Philippines; location of type not known to author.

Description: This description is based on two complete and two incomplete specimens. One intact specimen is spirally coiled but the other not. Estimated length of coiled specimen 14 mm and width 2·2 anteriorly; of other specimen 9 × 1·7 mm. Anterior extremity of trunk of coiled animal formed into a soft cap which is marked off from trunk by a rim; it is not an aspidosiphonid shield because it is not hardened and because introvert arises centrally and not ventrally to it. No shield-like structure in other specimen. Posterior region of introvert and anterior trunk bears flask-shaped papillae. Much of trunk carries numerous small hemispherical or rounded holdfasts, capped with a brown-black, forked structure of variable size, those on outer (dorsal?) side being largest. Single-pointed part of forked structure usually directed anteriorly.

Introvert about three quarters as long as trunk, bearing anteriorly numerous small, blunted hooks. One long nephridium. Intestine short and although convoluted seems not to be coiled. Retractor single, arising without bifurcation from posterior extremity of trunk.

Systematic position: There is no doubt that these specimens from *Heterocyathus* are a *Phascolion*. The single nephridium, the presence of holdfasts on the trunk and the absence of shields support this conclusion. The shape of the pointed structure of the holdfasts and the internal anatomy of the animal correspond to those of *Phascolion collare*, a species previously reported from shells. No three or five

pronged structures like those described for *P. tridens* Selenka & de Man are present in the Western Australian specimens. The specimens are closely related to *P. robertsoni* Stephen & Robertson, 1952, to *P. pacificum* Murina, 1957a and especially to *P. ikedai* Sato, 1930, reported from the coral *Stephanoceris*.

Distribution: (1) in Australia: north-west Australia.

(2) elsewhere: Philippines (Pangola, Uhoy, Bohol) in shells of *Strombus, Cerithium* and *Turbo;* Zanzibar in *Dentalium* shells; Makassar St. (at 2 000 m) and Bali Sea (at 1 951 m).

Specimens examined and localities: Western Australia—5 specimens in colitary coral, *Heterocyathus* sp. dredged at Norbill Bay, Dampier Archipelago WAM 36-73; also 2 specimens from *Heterocyathus* from Phillips Beach, Dampier Archipelago, AMS W5497. One retained in S.A. Museum (SAM E1188).

Phascolion cronullae n.sp.

Location of type: Australian Museum, Sydney; specimen in shell of *Gazameda gunni* (Reeves) off Cronulla, New South Wales.

Description: Trunk spirally twisted, about 9-20 mm long and with maximum width 3-4·5 mm. Introvert about as long as trunk and 1·5 mm wide. Body wall of introvert and anterior trunk is thick; that of part enclosed in shell of mollusc is thin, transparent and often fragile, except posteriorly where it is thicker.

Anterior extremity of introvert slightly bulbous and with small, scattered hooks 0·05-0·08 mm long. Anteriormost hooks are largest and straightest; more posterior hooks shorter and more recurved. Small papilla-like swelling present at base of hooks.

Introvert and trunk covered with papillae varying considerably in size and shape. Papillae on introvert smallest, with height greater than width, and with pointed and extended tips. Papillae on anterior trunk largest, 0·10-0·35 mm tall and 0·05-0·15 mm wide, some being urn-shaped and other more bulbous. Most terminate in a single tip, making papillae appear mamillate, but others, especially most anterior, may possess 2, 3 or 4 tips or prongs, then resembling to some extent the "four-armed cross" shown for *Phascolion convestitum* by Sluiter (1902: 32). Surface of trunk posterior to region with pointed papillae covered with numerous, closely packed, rather flat, pale coloured papillae, elliptical in shape. Thin walled part of trunk bears prominent, scattered holding or adhesive papillae about 0·1-0·2 mm tall and 0·15-0·25 mm wide, brown to dark red-brown in colour and usually lying with their blunted tips directed anteriorly. Between holding papillae and over rest of posterior surface lie numerous flat, pale, hemispherical to elliptical papillae.

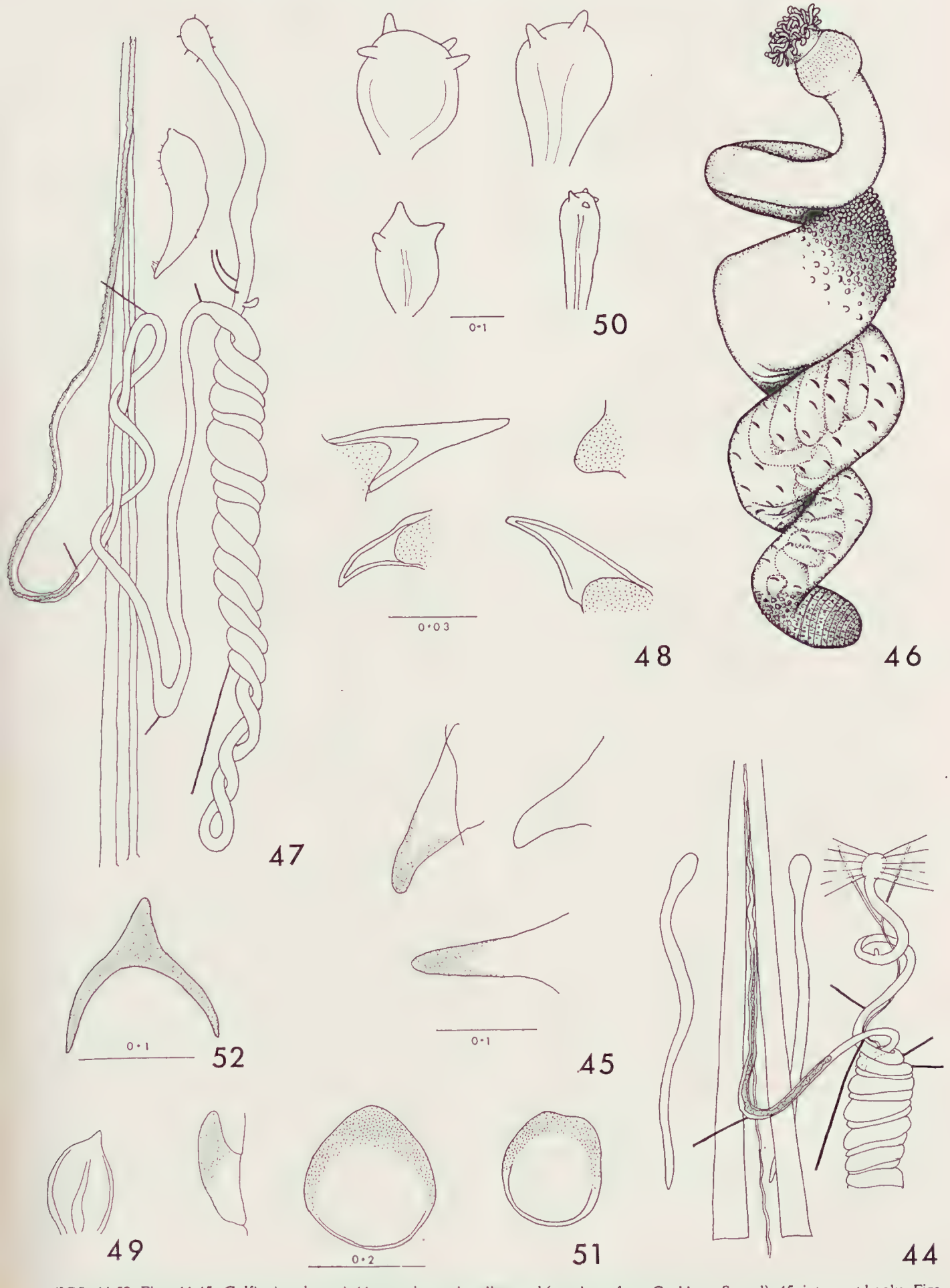
Longitudinal musculature continuous. Two retractor muscles, one usually stronger than other, arise separately at base of trunk. Alimentary canal complexly looped and coiled, with its oesophageal section fixed to the thinner retractor. Intestinal loops held in position by fixing muscles arising from anterior and posterior body wall. Posterior section of intestine may be wound into a loose spiral. Rectal caecum present and from nearby intestinal wall a pair of fastening muscles run to body wall (sometimes two strands may fuse before reaching body wall). Contractile vessel, without villi, attached to dorsal surface of oesophagus. No spindle muscle posteriorly. A single nephridium, fixed for most of its length.

Systematic position: These specimens resemble *P. convestitum* Sluiter, 1902 in possessing some anteriorly placed trunk papillae which possess 1-4 points. I have, however, compared them with Sluiter's type and consider them different. Sluiter's specimens, both labelled "types", are pyriform and bottle shaped and not coiled, and lack holdfast papillae with horny rims. The four-armed cross-like papillae are very numerous, more slender and extended than on the Australian specimens. Sluiter says that the nephridium of his species lies on the left side of the animal while in the Cronullan specimens it is clearly on the right. Sluiter does not mention the presence of a caecum nor of two fasteners that connect the rectum near the caecum and the body wall.

The Australian specimens differ from *P. strombi* (Montagu, 1804), in possessing anteriorly placed trunk papillae with 1-4 points. No such papillae are mentioned or illustrated by Théel (1905) where he redescribes the species, nor by Gerould (1913), nor in specimens collected by me at Roscoff, France (SAM E1183) nor in those dredged at 43° 03' N, 65° 30' W and sent to me by Dr. E. Cutler (Univ. of Utica, U.S.A.).

P. cronullae differs from *P. temporariae* Edmonds, 1976 from New Zealand in the shape of the introvert hooks and from *P. tortum* Edmonds, 1976, also from New Zealand, in the nature and position of the "ventral" retractor.

Commensal: I am indebted to Miss E. Pope of the Australian Museum, Sydney for the following information. "A polychaete of the family Syllidae was found in most of the shells containing a sipunculan. The polychaete seemed to be entwined with the *Phascolion* with its head near a point at the



FIGS. 44-52. Figs. 44-45, *Golfingia schuettei;* 44, anterior region dissected (specimen from Cockburn Sound); 45, introvert hooks. Figs. 46-51, *Phascolion cronullae;* 46, entire specimen; 47, anterior region dissected; 48, introvert hooks; 49-50, papillae from anterior trunk; 51, holdfasts from trunk. Fig. 52, *Phascolion collare;* hardened part of holdfast.

base of the introvert of the sipunculan. Of 74 randomly selected shells, 10 (13·3%) contained living molluscs, 46 (62%) contained *Phascolion* worms and 18 (24%) were empty. Syllids were present in 40 (87%) of the 46 tubes that contained the *Phascolion*." Dr. P. Hutchings of the Australian Museum has identified the polychaete as *Syllis (Toposyllis) armillaris* (Mueller).

Symbiotic associations between species of *Phascolion* and a number of other animals, including the syllid *Langerhansia cornuta* (Rathke) have been previously reported (Stephen and Edmonds 1972 p. 342).

Distribution: Known only from the type locality.

***Phascolion dentalicolum** Sato

Phascolosoma dentalicolum Sato, 1937 p. 165, pl. 4, figs. 20-21, text figs. 10-14; Cutler, 1977 p. 145, fig. 8.

Location of type: Saito Ho-on Kai Museum, Sendai, Japan; type locality, Onagawa Bay, north-east Honshu, at 23 m.

Description: Found in shells of *Dentalium* sp. Introvert 15 mm, trunk 15 mm. Small spines or hooks on introvert. Holding papillae on trunk low and laterally compressed. Two retractors. Single nephridium. Nephridiopore posterior to anus. Rectal caecum present.

Australian record: Great Australian Bight (off South Australia) 37° 28′ S, 138° 55′ E at 1 360 m (18) (Cutler, 1977). Specimens from small twisted gastropod shells.

Distribution: (1) in Australia: off South Australia.

(2) elsewhere: North-east Honshu, Japan.

***Phascolion pacificum** Murina

Phascolion pacificum Murina 1957b pp. 1777-1781, figs. 2a, 2b, 3a-e; 1972 p. 306; Cutler, 1977 p. 146.

Location of type: Not known to author; type locality Kurile-Kamchatka Trench at 6 156-6 860 m.

Description: Introvert with very small hooks. Trunk thin, small and grey-yellow. Single retractor with three roots. Caecum situated half or third of way from anterior end of trunk. Nephridia fastened to body wall for whole length.

Australian record: Great Australian Bight (off South Australia) 37° 28′ S, 138° 55′ E at 1 320-1 340 m (1) (Cutler, 1977 p. 146); specimen in empty gastropod shell.

Distribution: (1) in Australian: off South Australia.

(2) elsewhere: North-west Pacific Ocean, Peru-Chile Trench, Antarctica, Pacific and Indian Oceans.

Genus **Onchnesoma**

Onchnesoma Koren and Danielssen, 1875 p. 133; 1877 p. 142; Selenka and de Man, 1883 p. 130.

Description: Small sipunculans, usually pear or club-shaped. Introvert very long and without hooks and spines. Anus lies on introvert, well forward near mouth. Tentacles few or absent. Trunk covered with papillae of varying size and shape. Longitudinal musculature continuous. Single retractor arising from posterior of trunk. One nephridium.

Type species: *Onchnesoma steenstrupii* Koren & Danielssen, 1875.

***Onchnesoma steenstrupii** Koren & Danielssen

(Fig. 8)

Onchnesoma steenstrupii Koren & Danielssen, 1875 p. 133; 1877 p. 142, pl. 15, figs 28-36; Théel, 1905 pp. 93-96, pl. 10, figs 151-152, pl. 11, figs 157-172, pl. 13, fig. 185; Cutler, 1973 pp. 164-166.

Location of type: Not known to author; specimen from Kristiansund, Norway.

Description: Cutler (1973 p. 164) says that the worms have been aptly referred to as "a tiny football on a string". Trunk small, pyriform; length 1·0-2·5 mm, maximum 4 mm and width 0·8-1·3 mm (2 000 specimens sampled—Cutler, 1973). Introvert 5-10 times length of trunk, lacking tentacles and hooks. Only one introvert retractor. Anus lies well forward on introvert just posterior to mouth.

Remarks: The species is well known in the north Atlantic. It is distinguished from *Golfingia trichocephala* (Sluiter) by the position of its anus and the presence of only one retractor and one nephridium.

Australian record: New South Wales; off Broken Bay (33° 34'5S, 152° 06'5E) (7) Murina, 1972 pp. 164-166, 304-305.

Distribution: (1) in Australia: New South Wales.

(2) elsewhere: Iceland, Scandinavia, North Sea, North Atlantic, South-West Africa and Mediterranean.

Genus **Themiste**

Themiste Gray, 1828 p. 8, pl. 6, figs 4, 4a; Stephen, 1964 p. 458; Rice and Stephen, 1970 p. 66; Stephen & Edmonds, 1972 p. 193.

Dendrostomum Grube & Oersted, 1858 p. 118; Fisher, 1952 p. 404.

Dendrostoma Keferstein, 1865 p. 438; Selenka & de Man, 1883 p. 83.

Description: Trunk usually pear-shaped, sometimes elongate and slender; strongly contracted specimens may be globose. Tentacles surround mouth and branching; consisting of 4-8 stems which divide and sub-divide to form pinnately or palmately arranged tentacules. Hooks or spines may be present on introvert. Longitudinal musculature continuous. Retractor muscles two (rarely four). Spindle muscle not attached posteriorly. Two or more (usually three) fastening muscles to intestine. Two free nephridia. Contractile vessel usually well developed and bearing few to many villi which may be short or very long. Nuchal organ prominent in some species.

Type species: *Themiste hennahi* Gray (= *Dendrostomum peruvianum* Collin).

Remarks: Specimens of this genus have been collected along the coast of all the States of Australia. *T. lageniformis* is found in coral, in clumps of mussels and under stones. *T. cymodoceae* and *T. dehamata* are found in mud, in sand and in the roots of marine angiosperms. *T. huttoni*, *T. fusca* and *T. variospinosa* are often found in burrows in calcareous rocks or in cracks.

All the known Australian species have contractile vessels with numerous short villi. Specimens of *T. lageniformis*, *T. fusca*, *T. variospinosa*, *T. huttoni* and *T. cymodoceae* are usually pyriform, the last two and especially *T. cymodoceae* tending to be large and stout. *T. dehamata*, however, is more slender and elongate.

I am considering as one species the large specimens of *T. dehamata* collected in New South Wales (amongst them the type) and some smaller ones not uncommon in South Australia and Victoria. I have found it difficult to separate them other than on the basis of size. The relationship between them resembles in some ways that which Fisher (1952 p. 418) found between *T. dyscrita* (Fisher) and *T. zostericola* (Chamberlin). Eventually the larger New South Wales and the smaller southern forms may prove to be two species.

Subgenera of **Themiste**

On the basis of the number of retractor muscles and the length of the contractile tubules or villi the species of *Themiste* fall into three groups which I propose be regarded as sub-genera.

1. *Themiste (sensu stricto)* n. subg.

Diagnosis: Two retractor muscles. Contractile tubules or villi long and thread-like.

Type species: *Themiste hennahi* Gray.

Hooks or spines present	Hooks or spines absent
T. alutacea (Grübe)	*T. dyscrita* (Fisher)
T. blanda (Selenka and de Man)	*T. hennahi* Gray
T. hexadactyla (Sato)	*T. lissa* (Fisher)
T. petricola (Amor)	*T. perimeces* (Fisher)
T. pyroides (Chamberlin)	*T. schmitti* (Fisher)
T. rosacea (Amor)	*T. zostericola* (Fisher)
T. spinifera (Sluiter)	
(hooks sometimes reported to be lacking in *T. alutacea*).	

2. *Lagenopsis* n. subg.

Diagnosis: Two retractor muscles. Contractile tubules or villi short and finger-like.

Type species: *Themiste lageniformis* Baird.

Hooks or spines present	Hooks or spines absent
T. fusca (Edmonds)	*T. cymodoceae* (Edmonds)
T. huttoni (Benham)	*T. dehamata* (Kesteven)
T. minor (Ikeda)	*T. elliptica* (Sato)
T. variospinosa n. sp.	*T. fisheri* (Amor)
	T. lageniformis (Baird)
	T. tropica (Sato)
	T. robertsoni (Stephen and Robertson)
	(in *T. robertsoni* the tubules are described as being "only of moderate length and fairly numerous").

3. *Stephensonum* n. subg.

Diagnosis: Four retractor muscles.

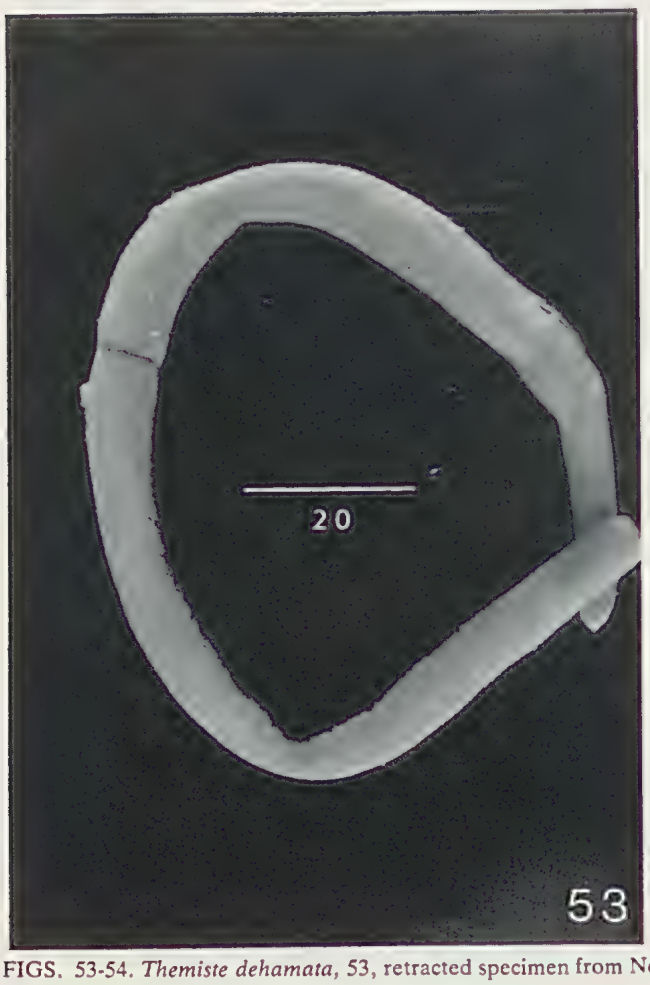
Type species: *Dendrostomum stephensoni* Stephen.

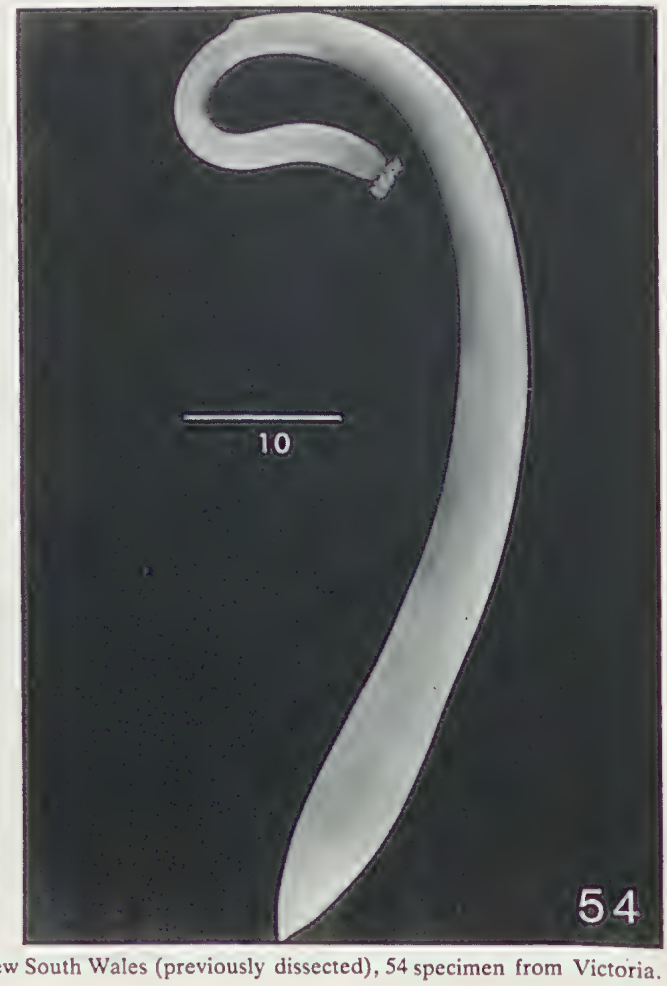
Hooks present	Hooks absent
T. pinnifolia (Keferstein)	*T. stephensoni* (Stephen)

Remarks: In *Themiste* s.s. the contractile tubules are usually few and in *Lagenopsis* they are numerous to very numerous. All *Themiste* species reported from Australia are members of the subgenus *Lagenopsis*.

KEY TO SPECIES OF *THEMISTE (LAGENOPSIS)* KNOWN FROM AUSTRALIA

1. Specimens with introvert hooks 2
   Specimens without introvert hooks 4
2. Hooks of almost uniform size 3
   Hooks of markedly different size, which are very irregularly directed ..... *Themiste variospinosa* n. sp. (p 42)
3. Hooks few and scattered; specimens usually small (trunk less than 15 mm), body wall thin and sometimes nearly transparent, retractors not stout, intestinal spiral rather loosely wound ..... *Themiste fusca* (p. 40)
   Hooks many and prominent, extending over most of the introvert and even posterior to the anus; specimens may be large and stout, body wall thick, villi of contractile vessel crowded, intestinal spiral usually tightly wound ..... *Themiste huttoni* (p. 36)
4. Specimens slender, size medium to very long; two dorsal stems of tentacles usually longer than two ventral stems; tentacles plumose and flecked at their tips; nuchal organ usually prominent ..... *Themiste dehamata* (p. 34)





FIGS. 53-54. *Themiste dehamata*, 53, retracted specimen from New South Wales (previously dissected), 54 specimen from Victoria.

Specimens stout rather than slender and pyriform or even sub-globular in shape; stems of tentacles about equal size 5

5. Specimens small to medium in size; tips of tentacles not pigmented; usually collected in clumps of mussels or in coral ..... *Themiste lageniformis* (p. 41)

Specimens medium to large in size; tips of tentacles pigmented; usually collected in roots of marine angiosperms ..... *Themiste cymodoceae* (p. 38)

Themiste (Lagenopsis) dehamata (Kesteven)

(Figs. 53-57)

Dendrostoma dehamatum Kesteven, 1903, pp. 69-73, pl. 7, figs 1-6.

Dendrostomum dehamatum: Edmonds, 1956, p. 296, pl. 1, fig 1.

Themiste dehamata: Stephen & Edmonds, 1972, p. 198.

Location of type: Australian Museum, Sydney; specimen from Balmoral, Sydney Harbor, New South Wales.

Re-examination of three specimens: This redescription is based on three of Kesteven's original specimens from Balmoral, New South Wales (SAM E1210) but not the type material.

Specimens very long and slender. According to Kesteven (1903 p. 69) they were collected on the beach "at a time when there had been much rain and heavy storms". One cannot then discard the possibility that the unusual shape of the specimens is the result of the changes which take place when sipunculans are placed in hyposmotic solutions. Fisher (1952 p. 17) reported that three specimens of *Themiste perimeces*, washed up on the beach after a storm, were "unnaturally lengthened".

Body sub-cylindrical, slender, curved almost into a circle, tapering posteriorly and pointed. Trunk of largest 170 mm long and 7 mm wide posteriorly. Off-white to grey in colour with posterior region darker and almost black in one specimen. Skin smooth but marked into small rectangular areas by fine intersecting lines. Small, flat to slightly elevated papillae with small, white, centrally-placed glandular pores are present in the middle of the rectangular areas. Posteriorly placed trunk papillae black in one specimen.

Introvert, not well differentiated from trunk, with maximum length estimated as 50 mm; grey to yellow and without hooks. Tentacles plumose, flecked purple brown and, according to Kesteven, arranged "in four stems, two of two and two of three primary branches. In some specimens, however, the division between the branches extends right down to the circumoral muscular ridge, in which case there are eight branches". The individual tentacules seem arranged largely in a pinnate manner along the extended oral grooves (Kesteven, 1903, pl. 6, fig 2). Nuchal organ prominent.

Two very long retractors, arising in posterior half of trunk and separate for most of their length. Anteriorly, however, they are rolled to form two halves of a "tube" containing oesophagus and contractile vessel. Alimentary canal very long. Oesophagus runs to or near to base of retractors, where it is fastened, then loops up anteriorly and coils into a very long intestine with spirals extending into posterior third of trunk. Rectum very long and carrying a caecum. Anus and nephridiopores at about same level, although in Kesteven's fig. 1 the anus is just anterior. Rectal membrane present but not as prominent as that shown for *T. fisheri* (Amor, 1964, p. 4, fig. B).

There are three main fastening muscles and a spindle muscle. F1, arising at or just posterior to base of retractors (= mes' and mes" of Kesteven fig. 1), may be single or double; if double the roots may arise at slightly different levels. F1 is attached to oesophagus near posterior extremity of contractile vessel. F2, arising from left side of and near to nerve cord, runs to rectum near caecum, and usually supplies a well-developed series of connectives to posterior oesophagus near intestinal spirals (=spm' of Kestevens fig. 1). F3, arising from right side of nerve cord (more anteriorly than F2), runs to rectum at about level of caecum (=spm" of Kesteven's fig. 1). Spindle muscle arising from rectum just posterior to caecum, traverses whole length of intestinal spiral but is not fixed posteriorly. Contractile vessel prominent, bearing very numerous, short villi (much like those of *T. lageniformis, T. cymodoceae* and *T. huttoni)* clustered along its dorsal surface. Posterior villi longer and forming short branches. Nephridia slender, free and about one third as long as trunk.

Remarks on some smaller specimens: After considerable deliberation I am referring a large collection of smaller specimens of *Themiste* from South Australia and Victoria to this species. They differ from the Sydney specimens most notably in size.

Trunk of largest 75 mm long but mostly 30-50 mm long and width 3-4 mm. Colour light grey to pale pink but anterior region sometimes yellowish. Mouth surrounded by four groups or stems of branching tentacles, two larger stems being placed dorsally between a prominent nuchal organ and two smaller stems ventrally. Tentacules often dark purple, arranged pinnately along stems but at extremities of smaller branches more palmately. Introvert without hooks or spines and often not well marked off from trunk.

FIGS. 55-56. *Themiste dehamata,* tentacular crown of two specimens; 55 from Victoria, 56 from South Australia.

Internally as for *T. dehamata.* Two points of difference, however, sometimes noticed; (1) the rectal membrane is much more prominent than in the four specimens described above and (2) there are some variations in the points of attachment of the intestinal fasteners. F1 may consist of a membrane or three roots of different lengths. F2 may connect with upward loop of oesophagus more anteriorly and an additional F2a may connect the posterior oesophagus and rectum. F3 seems invariable. Spindle muscle as in Balmoral specimens. Spherical eggs 0·15-0·18 mm in diameter in some specimens.

Systematic position: I have not been able to distinguish satisfactorily between the larger specimens of *T. dehamata* from New South Wales and the smaller specimens of *Themiste* from South Australia, Victoria and Western Australia other than on their size. Eventually some other worker may be able to show that they are different. The relation between the large and small specimens is much like that between *T. zostericola* and *T. dyscrita* (Fisher, 1952 p. 418).

Themiste fisheri (Amor, 1964) from Argentina is closely allied to *T. dehamata.* Amor (1964 p. 469) considered that the tentacles of her specimens arose from six stems. While this may be so I contend that her fig. 3a could be interpreted to show the presence of four primary stems, her (1 & 2), 3, 4, her (5 & 6). The main differences between the two species are that *T. dehamata* has a caecum while *T. fisheri* has not, that F1 and F2 arise from different positions in the two and that the spindle muscle of *T. fisheri* seems to arise more anteriorly. None of these points is very significant taxonomically except for that of the caecum. Previous Australian record: New South Wales (Kesteven, 1903).

Distribution: in Australia: New South Wales, Victoria, South Australia and Western Australia.

Specimens examined and localities: New South Wales—Balmoral, Sydney Harbor (4) SAM E1210—part of Kesteven's collection. Victoria—Western Port Bay (2) SAM E1211 and (1) SAM E1212; Port Phillip Bay (4) SAM E1222. South Australia—chiefly amongst the roots of the marine angiosperms *Amphibolis, Posidonia and Zostera"* Outer Harbor (7) SAM E1214 Aldinga reef (8) SAM E1216 and SAM E1217; Proper Bay, Port Lincoln

(10) SAM E1218; Coffin Bay (Eyre Peninsula) (3) SAM E1219; Cape Jervois (5) SAM E1221; Emu Bay (Kangaroo Is.,) (6) SAM E1213; Sellick's reef "in roots of *Amphibolis*" (5) SAM E1225. Western Australia—Cottesloe (3) SAM E1248.

Themiste (Lagenopsis) huttoni (Benham)

(Figs. 60-64)

Phascolosoma huttoni Benham, 1904, p. 307.

Dendrostomum huttoni: Edmonds, 1960, pp. 164-165, pl. 3, text figs. 5-6.

Themiste huttoni: Stephen & Edmonds, 1972, p. 204.

? *Dendrostoma signifer* (in part) Selenka & de Man, 1883, pp. 86-87; Augener, 1903, p. 337; Fischer, 1914, p. 11; Fischer, 1919a p. 282.

Location of type: Not known by author; specimen from New Zealand.

Introduction: Selenka & de Man (1883, p. 87) considered a specimen from Sydney, with backwardly directed hooks 0·2 mm long, to be "an armed variety of *Dendrostoma signifer*" (= *T. lageniformis)*. The same term was used by Augener (1903, p. 37) for some specimens from New Zealand, by Fischer (1914), p. 37) for some specimens from New Zealand and by Fischer (1919a, p. 282) for specimens from Albany, Western Australia. None of these authors discussed the taxonomic problem of the presence or absence of introvert hooks. Awati & Pradhan (1935, p. 10), however, in their account of "*D. signifer*" from India state that feebly developed hooks are found on the introvert of the younger stages but that they "fall off" in adults. This does not appear to be so for *T. lageniformis* in Australia. None of the specimens in my collection from Yeppoon, Dunwich and Darwin possess hooks, although they range from young to adult animals. On the other hand all the armed specimens of *Themiste* sent from New South Wales and Western Australia (including some with a trunk 40 mm long and others that contain eggs and consequently are adults) are heavily armed. At present I take the view that since all the specimens collected from any one locality are either armed or unarmed and not a mixture of the two they belong to closely related but different species. If in the future specimens with and without hooks are collected from the same habitat the decision would have to be reconsidered. Benham (1904) possibly took this view (although he did not explicitly state it) when he called the "armed variety" from New Zealand a new species, *D. huttoni*. Cutler (1973, p. 161) says, with justification, that the hooks of some species of *Golfingia* may be lost. While it is possible and even likely that some or all of the hooks may be lost from a specimen of *Themiste* for reasons concerned with its environment or method of collection, my observatons lead me to the hypothesis that *T. lageniformis* is one species and that the armed form is another.

The specimens of *Themiste* from some localities e.g. South Australia, are small and often almost transparent and the introvert hooks few in number, small, almost uniform in size and distributed over a small area of the introvert. Specimens from New Zealand, Tasmania, Western Australia and New South Wales are larger and more robust and the introvert hooks more numerous and larger but, while still almost uniform in size, they extend over much of the introvert, even to a point posterior to the anus. In another group of specimens from Queensland the hooks are noticeably different; some are very large and others almost rudimentary, they are irregularly arranged and point in different directions. For these reasons I regard the armed specimens of *Themiste* closely resembling the unarmed *T. lageniformis* as falling into three groups and, because any collection from one locality contains only one group and not two or more, I consider each group on morphological grounds to be a separate species. The specimens from New Zealand, Tasmania, Western Australia and New South Wales are *T. huttoni* (Benham), those from South Australia are *T. fusca* (Edmonds) and those with variable spines are a new species, *T. variospinosa*.

Description: The following description of *T. huttoni* is based on specimens from New Zealand, New South Wales, Queensland, Tasmania and Western Australia.

(1) Trunk of New Zealand specimens 16-35 mm long with maximum width about 6 mm, grey in colour, thick walled, smooth and pointed posteriorly. Estimated length of invaginated introvert about a quarter that of trunk. Dissected introvert shows that tentacles arise from a number of stems and that black, posteriorly directed hooks or spines are present. Hooks almost uniform in shape and size and their field does not extend as far as the anal aperture.

Two stout retractors arising from posterior half of trunk and separate for most of their length. Alimentary canal consisting of descending and ascending oesophageal loops, a long intestinal spiral and a rectum with a caecum. Contractile vessel attached to anterior oesophagus and bearing very numerous, short, finger-like villi, the most posteriorly placed of which often form short branches. Fixing muscles F1 and F3 well developed but F2 usually reduced. F1 arises from body wall anterior to and left of point of attachment of left retractor and is fastened to oesophagus just posterior to termination

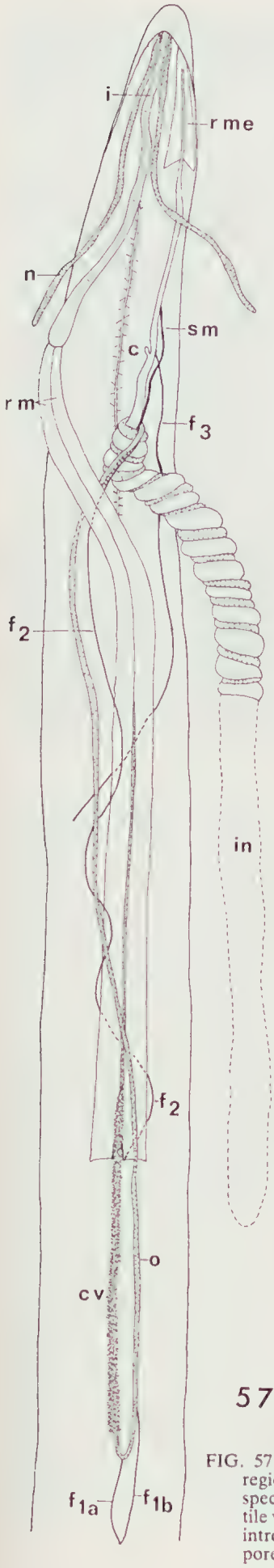


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FIG. 57. *Themiste dehamata*, anterior region dissected (one of Kesteven's specimens). c, caecum; cv, contractile vessel; f1-f3, fastening muscles; i, introvert; in, intestine; n, nephridiopore; o, oesophagus; rm, retractor muscle; rme, rectal membrane; sm, spindle muscle.

of contractile vessel. F3 attached to rectum near rectal caecum. F2 represented by a number of muscular threads arising from upward loop of oesophagus which converge and join rectum near caecum. Spindle muscle, arising anteriorly from rectum, not attached posteriorly. Wing muscle present. Two free tubular nephridia, opening just posterior to anus. Two eyespots near brain and a nuchal organ lying at dorsal extremity of introvert. Papillae on body wall small, flat with a small white pore centrally. Eggs spherical, 0·17-0·19 mm in diameter. Skin at posterior extremity traversed by fine lines.

(2) Trunk of Western Australian specimens 10-28 mm long and with maximum width 2·5-4·4 mm, curved inwards on the ventral side and with posterior extremity bluntly pointed. Tentacles as in New Zealand specimens but pigmented at their base. Introvert hooks dark brown to black, most pointing posteriorly. The field of hooks in all seven specimens, however, extends right round the introvert and well posterior to the anus (something very unusual in a sipunculan). F1 fixes oesophagus to body wall at a point between base of retractors. F2, F3, caecum, spindle muscle, nephridia and eyespots like those of New Zealand material.

(3) Specimens from New South Wales larger; trunk 12-55 mm long and maximum width 7-11 mm. Colour predominantly grey but with marked yellowish tinge. Armed area of introvert large but not extending posterior to anus as in specimens from Western Australia. F1 arises between retractors just to left of nerve cord. F2 not reduced, arising from body wall anterior to base of left retractor and running to posterior oesophagus; it may connect with rectum near the caecum. F3 as in New Zealand specimens. Hooks, diameter of base 0·15-0·25 mm and length 0·15-0·22 mm.

Systematic position: This species differs from *T. lageniformis*, *T. cymodoceae* and *T. dehamata* in the possession of introvert hooks. It differs from *T. fusca* which is smaller and in which the body wall is thinner, the nuchal organ more prominent, and the intestine shorter and more loosely wound. It differs from *T. variospinosa* in which the introvert spines vary very much in size, shape and orientation.

Previous Australian record: Sydney, New South Wales (Selenka & de Man, 1883).

Distribution: (1) in Australia: New South Wales, Tasmania, Western Australia and Queensland.

(2) elsewhere: New Zealand.

Specimens examined and localities: New Zealand —Stewart Is., (2) SAM E1228; east of Otago (1) trawled on "Tacaroa" SAM E1229. Tasmania—Coles Beach, near Devonport (1) SAM E1234;

Jacobs Boat Harbor (1) SAM E1235. Western Australia—Trigg Is., "in limestone reef" (7) SAM E1233 and (2) WAN 242/76; Cockburn Sound (2) WAM 32/73. New South Wales—Coffs Harbor (4) SAM E1236; Bottle and Glass Rocks (2) SAM E1237; Long Reef (1) SAM E1238. Queensland—Coloundra (6) "on exposed rocky shore" SAM E1239.

Themiste (Lagenopsis) cymodoceae Edmonds

(Figs 58 and 63)

Dendrostoma cymodoceae Edmonds, 1956 pp. 297-301, figs 15-16; Akesson, 1958, pp. 147-151 figs 66-67 and 219-222.

Themiste cymodoceae Stephen and Edmonds, 1972, pp. 197-198, fig. 102.

Location of type: Australian Museum, Sydney; specimen from Aldinga Reef, South Australia, amongst roots of the marine angiosperm *Amphibolis* (= *Cymodocea) antarctica.*

Description: Adults large, robust and elongate to pyriform in shape; trunk 50-90 mm long with maximum width of 15-25 mm posteriorly. Colour light to dark grey with tendency to yellow brown anteriorly; posterior region usually darker. Introvert cylindrical, relatively short, about 5-8 mm in diameter and lacking hooks and spines. Surface of introvert just posterior to tentacles smooth, pale and shiny or sometimes purplish and glossy. A light brown or yellow band often surrounds introvert near its middle or towards base. Trunk of fixed specimens tends to curve inwards slightly on ventral side. Body wall smooth, although covered with numerous flat, white papillae, 0·04-0·08 mm in diameter, each of which bears a white glandular opening at its centre. Body wall thick, especially posteriorly. Longitudinal and circular musculature continuous but internal coelomic wall traversed by oblique muscle striations.

Tentacles arising from four primary stems any of which may subdivide so that tentacles sometimes appear to be in 4-8 stems. Subsequent division or redivision of stems gives rise to small, finger-like, straw to purple-brown pinnately arranged tentacules. Tip of tentacules always darker than remainder. Tentacles (= stems and tentacules), relative to length of trunk seem smaller than those of *T. lageniformis* and are more bushy.

Internal anatomy resembling that of *T. lageniformis.* Two long, stout retractors fixed in posterior third of trunk. Oesophagus thin-walled, running between retractors as far as their base and then looping sharply upwards to a point near rectum; intestine long and spirally coiled. Rectum short and carrying a caecum. System of intestinal fasteners variable. Oesophagus always fastened near base of

FIG. 58. *Themiste cymodoceae,* (specimen from Aldinga Bay, South Australia).

retractors by 1-4 short threads (F1), usually arising between bases of retractors on left side of nerve cord. F2, arising near left retractor and connecting with upward loop of oesophagus near the first spiral, may or may not be present. F2 may bifurcate or an additional fastener (F2a), arising close to F2, may also connect with oesophagus. In a few specimens F2 may connect solely or in part with last or penultimate intestinal spiral. F3, present in all specimens, is shorter and stouter than F2, arises on right side of nerve cord in anterior half of trunk and connects with last intestinal spiral or rectum where latter joins the intestine. Spindle muscle strong, arising anteriorly from beneath a rectal membrane, but not attached posteriorly. Contractile vessel attached to oesophagus as far as base of retractors and bearing very numerous short sometimes branching villi, which are larger and very densely clustered posteriorly. Nephridia thin, brown in colour, free, about one third as long as trunk and opening at about level of anus or usually just posterior to it. Gonads at base of retractors. Nuchal organ not as prominent as in *T. dehamata.*

Systematic position: *T. cymodoceae* is closely related to *T. lageniformis.* Although in 1956 I admitted that the two might be extreme varieties of the same species I now consider them different. *T. cymodoceae* grows to a larger size, its tentacles are more bushy and plumose and are pigmented at their

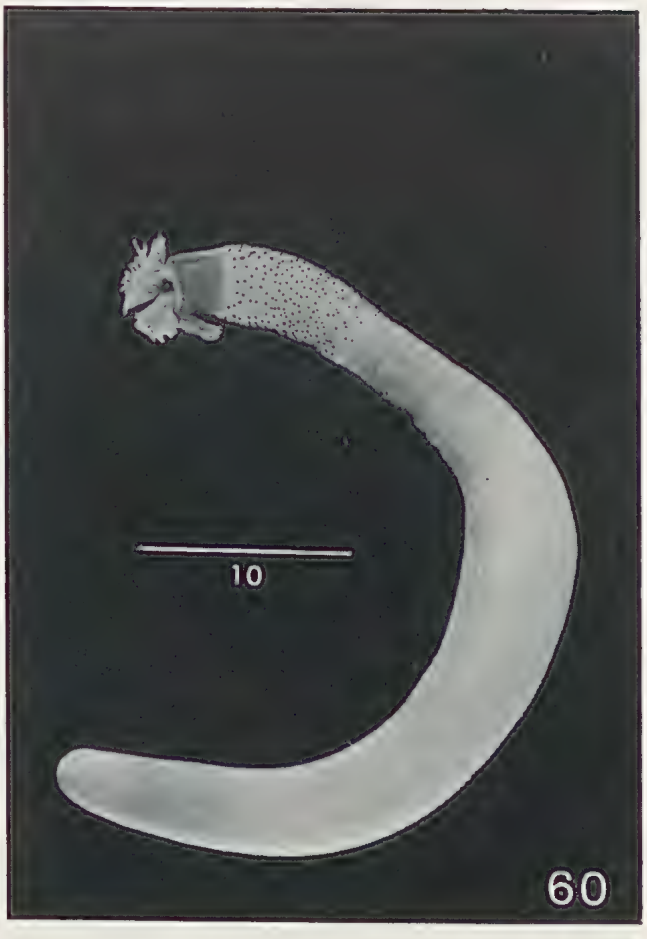


FIG. 59 *Themiste fusca*, (specimen from South Australia).

FIG. 60. *Themiste huttoni*, (specimen from Long Reef, New South Wales).

FIG. 61. *Themiste lageniformis*, (specimen from Curtis Is., Queensland).

FIG. 62. *Themiste variospinosa*, (specimen from Queensland).

tips and there is usually greater variation in the arrangement of its intestinal fasteners. There is, however, little difference in the internal anatomy of the two species. At Aldinga reef, St. Vincent Gulf, South Australia, the type locality, *T. cymodoceae* lives amongst the tangled roots of *Amphibolis* (= *Cymodocea*) *antarctica* and the sand and debris contained in them. It lives in a cavity which is formed as the animal grows in the roots. It seems to be almost sedentary; it scarcely moves and shows little inclination to burrow when it is placed on sand in an aquarium. *Amphibolis* normally lives below the level of inter-tidal reefs. Patches of it occur, however, on the outer edges of reefs which are well washed by waves and where there are tidal runs and drains. I have not found the species in burrows in rocks. *Themiste fusca*, however, occurs in burrows on the same reef at a higher level near the shore. Although I have collected about 400 specimens of *T. cymodoceae* at this locality I have not found any which carry introvert hooks. The specimens of *T. lageniformis* which I have identified from Australia have been associated with mussel clumps or coral rock.

The relation between *T. cymodoceae* and *T. lageniformis* is very much like that between *T. zostericola* and *T. dyscrita* as described by Fisher (1952 p. 418).

Akesson (1958) made a careful study of the nervous system of *T. cymodoceae* and Edmonds (1957a & 1957b) studied its respiration and excretion. It is a good experimental animal in that it is very hardy; it seems reluctant, however, to feed in the laboratory. Previous Australian record: South Australian (Edmonds, 1956).

Distribution: Known only from the shores of St. Vincent Gulf, South Australia.

Specimens examined and localities: South Australia—Aldinga reef (just north of Sellicks Beach), St. Vincent Gulf, "among roots of the marine angiosperm *Amphibolis (= Cymodocea) antarctica* (Labill.) Sonders & Ascherson", about 50 specimens comprising SAM E1191, E1193; Cape Jervis (2) SAM E1194.

Themiste (Lagenopsis) fusca (Edmonds)

(Figs. 59, 65-67)

Dendrostomum fuscum Edmonds, 1960, pp. 165-167, figs 7-9, pl. 3.

Themiste fusca: Stephen & Edmonds, 1972, pp. 200-201.

Location of type: Australian Museum, Sydney; specimen from Proper Bay, near Port Lincoln, South Australia. Specimens burrowing in a calcareous, intertidal reef.

Description: Specimens usually small. Trunk rarely as long as 20 mm and usually less than 15 mm; white, cream or light brown in colour. Body wall thin and sometimes semi-transparent. Introvert short. Tentacles white and branching, sometimes flecked with brown and arising from four primary stems. Introvert hooks black, blunt, posteriorly directed, 0·05-0·10 mm long, few in number and scattered. Numerous very small, circular, pale coloured papillae, largest and most prominent at base of introvert and on posterior trunk. Skin usually smooth but sometimes furrowed into small square or rectangular areas.

Two slender retractors arising in posterior region of trunk. Oesophagus fastened to body wall at base of retractors, then looping anteriorly as in *T. lageniformis* and *T. huttoni*. Contractile vessel with fewer and simpler (less branched) villi. Intestinal spiral loosely and sometimes irregularly wound consisting of 6-10 double spirals. Rectal caecum small. Spindle muscle arising anteriorly from rectum but not fixed posteriorly. Two nephridia short, free and with external openings just posterior to anus. Rectal membrane present. Fastening muscle F1 connects base of oesophageal loop to body wall at point bear base of left retractor and F3 holds last spiral of intestine. F2 may be complete, reduced or absent; if complete, it holds posterior oesophagus and if reduced it joins only the posterior oesophagus and posterior intestinal spiral and not the body wall. Gonads at base of retractors. Two eyespots. Nuchal organ present.

Systematic position: This species is closed allied to *T. huttoni* (Benham) and *T. minor* (Ikeda), the latter from Japan. It differs from *T. huttoni* in that in *fusca* (1) the specimens are smaller (2) the body wall is much thinner and often nearly transparent (3) the hooks are smaller, fewer in number and more scattered in their distribution (4) the retractors are weaker (5) the villi are fewer (6) the intestinal coil is shorter and more loosely wound and (7) the nuchal organ is more prominent.

The smallest specimens are not easily distinguished externally from some of *T. minor* (Ikeda) kindly sent to me from Matsuyami, Japan by Dr. O. Ochi (Ehime University). The Japanese specimens, however, are smaller, their system of fastening muscles and their contractile vessel seem simpler.

Both *T. cymodoceae* and *T. fusca* are found at Aldinga and Sellicks Reefs, South Australia, the former amongst the roots of the angiosperm *Amphibolis* on the lowest levels of the reef and subtidally, and the latter in burrows in the calcareous rock at higher levels near the shore.

Previous Australian records: South Australia (Edmonds, 1960).

Distribution: (1) in Australia: South Australia.

(2) elsewhere: New Zealand.

Specimens examined and localities: South Australia—Point Wittelbee, Eyre Peninsula (15) SAM E1240; Coffin Bay (16) "in calcareous reef between tide levels" SAM E1241; Kellidie Bay (near Coffin Bay) (7) "in limestone reef"; Port Willunga and Aldinga (both south of Adelaide) (30) SAM E1243; Encounter Bay (in limestone reef in front of Yilkie Post Office) (20) SAM E1249; Proper Bay, near Port Lincoln "burrowing in limestone reef exposed at mid-tides" (8) SAM E1242.

Themiste (Lagenopsis) lageniformis Baird

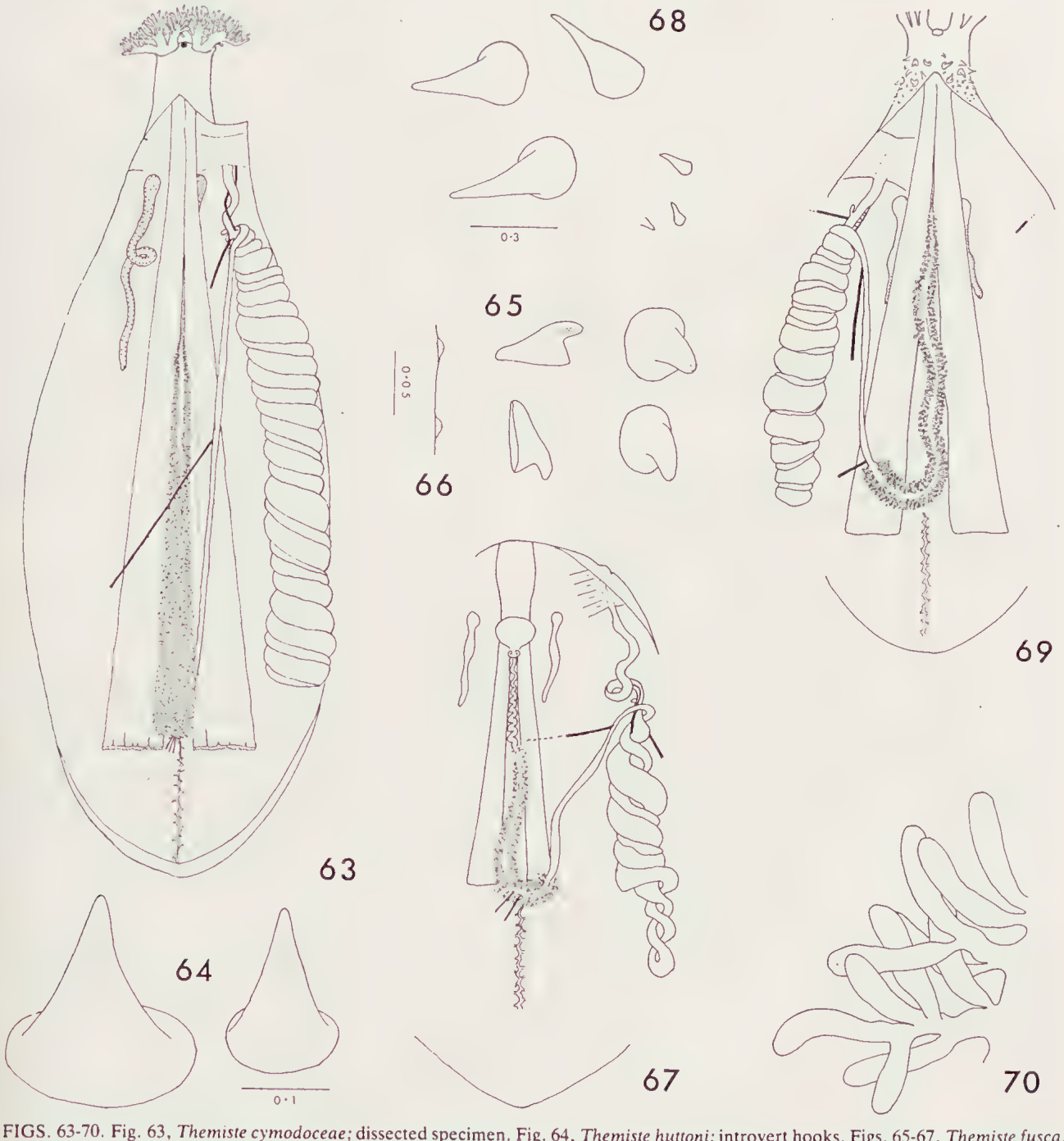
(Figs 61, 70)

Themiste lageniformis Baird, 1868, pp. 98-99, pl. 10, fig. 3; Rice and Stephen, 1970, pp. 66-67, pl. 3, figs 12-13; Stephen & Edmonds, 1972, p. 205.

Dendrostoma signifer Selenka & de Man, 1883, pp. 86-87, pl. ii, pl. 11, figs 163-164.

Dendrostomum signifer: Edmonds, 1956, p. 297, pl. 1, fig. 2.

Location of type: British Museum (Nat. Hist., London); specimen from Australia.



FIGS. 63-70. Fig. 63, *Themiste cymodoceae;* dissected specimen. Fig. 64, *Themiste huttoni;* introvert hooks. Figs. 65-67, *Themiste fusca;* 65, introvert hooks; 66, papillae on trunk (figs. 65 & 66 to same sale); 67, dissected specimen. Figs. 68-69, *Themiste variospinosa;* 68, introvert hooks; 69, dissected specimen. Fig. 70, *Themiste lageniformis;* branching contractile villi.

Description: Size and shape of specimens depending largely on whether or not they had been relaxed before fixation. Contracted specimens stout, pear-shaped or sub-spherical, relaxed ones longer and less stout. Trunk 5-33 mm long with maximum width in posterior third, flesh-coloured, light to dark grey or light to dark brown. Most tend to curve inwards on ventral side. Body wall appearing smooth although small, white, flat glandular pores present. Surface of unrelaxed specimens often divided into small rectangular areas by fine lines or ridges. Posterior extremity rounded or pointed.

Introvert short, 3-10 mm long, often darker in colour than trunk and often ringed anteriorly with a dark blue to black band. Tentacles white and not pigmented or flecked like those of *T. dehamata* and *T. cymodoceae;* arising from 4 primary stems any one of which may divide into two or more stems, the latter branching in turn to form tentacules. Consequently, if subdivision is near base of primary stem, number of stems may appear to be 5-8. Tentacules finger-like and relative to body length longer than those of *T. dehamata* and *T. cymodoceae.* Four primary stems form grooves along which food moves to mouth. Region of introvert just posterior to tentacles forming a smooth collar; a pigmented ring, if present, lying posterior to collar. All specimens listed below without introvert hooks, although collected at different times by different people.

Two very stout retractor muscles arising in posterior third of trunk. Oesophagus runs to base of retractors where it is held in position by a short, sometimes double, fastener (F1) and then loops anteriorly. Intestinal coil a well developed spiral; rectum short and carrying a caecum. In most specimens a second fastener (F2), arising near point of attachment of left retractor, is fixed to oesophagus near first intestinal spiral. F3, arising near right retractor, fixed to last or second to last spiral. Stout spindle muscle, arising anteriorly from beneath a rectal membrane, not fixed posteriorly. A tubular contractile vessel with numerous finger-like villi extending along the oesophagus to base of retractors; villi may form short branches near base of retractors but rarely extend a long upward loop of oesophagus. Two free, tubular nephridia, about one third as long as trunk, opening near anus or just posterior to it. Gonads at base of retractors; spherical eggs with diameter 0·18-0·20 mm. Nuchal organ not as prominent or as noticeable as in *T. dehamata* and *T. cymodoceae.* Brain with two eyespots.

Systematic position: *T. lageniformis,* probably better known as *T. signifer,* is a small to medium sized species, pyriform to sub-globose in shape and often curved inwards on its ventral side. It lacks hooks and its tentacles are not pigmented at their tips. The body wall is usually stout and thick. A dark blue-black band may ring the introvert anteriorly.

Previous Australian records: Queensland (Edmonds, 1956), Cape York (Selenka & de Man, 1883). "Varieties" with hooks reported from Sydney (Selenka & de Man, 1883), from Tasmania (Fischer, 1914) and Albany, Western Australia (Fischer, 1926) are being referred to other species. Baird's 1868 record is from "Australia".

Distribution: (1) in Australia: Queensland, Northern Territory and Western Australia.

(2) elsewhere: widely in the Indo-Pacific Region; West Africa, South Africa, Madagascar, India, Gulf of Manaar, Amboina, Japan, Philippines, New Zealand and Hawaii (SAM E1197).

Specimens examined and localities: Queensland —Dunwich (20) "in clumps of mussels, in front of the cemetry" SAM E1196 and (12) SAM E1207; Myora (10) SAM E1200; Cape Cleveland (2) SAM E1201; Cardwell (1) SAM E1202; Geoffrey Bay, Magnetic Is. (6) SAM E1203; Wellington Pt., Moreton Bay (8) SAM E1205; Wistari Reef, Capricorn Group (2) coll. of Prof. W. Stephenson; Yeppoon (5) coll. of Prof. R. Kenny; Rat. Is., near Pt. Curtis (7) AMS W2760. Northern Territory —Lee Point, near Darwin "in coral" (4) SAM E1208 and (4) SAM E1209. Western Australia—Broome (8) coll. from Hamburg Museum.

Themiste (Lagenopsis) variospinosa n.sp.

(Figs. 62, 68, 69)

Location of type: Australian Museum, Sydney; specimen from "coral clumps", St. Helena Is., Moreton Bay, Queensland.

Description: This species is distinguished from *T. huttoni,* which it closely resembles, by the spination of its introvert hooks.

Trunk 9-27 mm long and maximum width 4-7 mm in posterior third, with posterior extremity bluntly pointed and with surface smooth, grey in some and pinkish brown in others. Small flat, circular papillae, with a very small clear or white pore at centre, almost uniformly distributed over surface. Tentacles branching and arising from 4-5 stems (shown in two well-relaxed specimens). Nuchal organ present between two stems of tentacles on dorsal side. Introvert hooks sharp and black; those most anteriorly placed largest, 0·15-0·30 mm long, with most points directed posteriorly. Hooks most posteriorly placed smallest, 0·02 mm long, with tips directed anteriorly, posteriorly or at right angles to surface (hence name *variospinosa).*

Internal anatomy much like that of *T. huttoni*. Two strong retractors, arising in posterior half of trunk. Alimentary canal consisting of downward and upward loops of oesophagus, a spirally coiled intestine and rectum. Contractile vessel attached to downward loop of oesophagus and bearing villi not as densely packed as in *T. huttoni*. Posteriorly placed villi forming short branches and extremities of villi sometimes expanded into a small knob. Fastening muscle F1 arising to left of base of left retractor (as it does sometimes in *T. huttoni)* and connecting with oesophagus just posterior to extremity of the contractile vessel. F2 arising more anteriorly than F1 and connecting with posterior oesophagus and rectum. F3 short and strong. Spindle muscle not fixed posteriorly. Rectal caecum present. Nephridia two, free, tubular and arising just posterior to anus.

Systematic position: In the retracted state these specimens look very much like a *Golfingia*. Some expanded specimens, however, show that the tentacles arise from at least four stems each of which divides and subdivides to form tentacules. The species is closely related to *T. huttoni* and *T. fusca*. It differs from both in the nature and arrangement of its introvert hooks.

No previous Australian record.

Distribution: in Australia: only from the type locality (St. Helena Is., Moreton Bay).

Specimens examined and localities: Queensland—St. Helena Is., Moreton Bay "in coral clumps" SAM E1245 and same locality (5) SAM E1246.

Family Aspidosiphonidae and key to genera

Aspidosiphonidae Baird, 1868, p. 100; Stephen and Edmonds, 1972, pp. 215-216.

Description: Rather small sipunculans with either a hardened, horny, usually brown shield or a white, calcareous cap clearly marked off on anterior region of trunk. A caudal shield may be present at posterior extremity of trunk. Introvert lies ventral to shield or cap in all genera, except *Cloeosiphon*, where it arises from centre of cap. Longitudinal musculature continuous or in bundles, the latter sometimes anastomosing considerably. Two nephridia.

Type genus: *Aspidosiphon* Diesing, 1851.

KEY TO GENERA OF ASPIDOSIPHONIDAE KNOWN FROM AUSTRALIA

1. Anterior (anal) shield or cap present and posterior (caudal) shield as well 2
   Anterior (anal) shield or cap present but no posterior (caudal) shield 3
2. Longitudinal musculature of trunk wall forming bundles, which may anastomose considerably
   Paraspidosiphon (p. 49)
   Longitudinal musculature of trunk wall continuous
   Aspidosiphon (p. 43)
3. Longitudinal musculature of trunk wall continuous (anterior cap rounded, calcareous and pineapple-like). Introvert from middle of cap ..... *Cloeosiphon* (p. 54)
   Longitudinal musculature of trunk wall forms bundles, which may anastomose. Anterior cap has shape of a truncated cone. Introvert arising ventral to cap *Lithacrosiphon* (p. 54)

Remarks: Stephen (1964, p. 457) split off from *Aspidosiphon* a new genus, *Paraspidosiphon*, in which the longitudinal muscles are grouped into bundles, sometimes with much anastomosation. Stephen regarded the condition of the longitudinal muscles of considerable taxonomic importance in the phylum. Stephen and Edmonds (1972) followed Stephen's lead. Neither Cutler (1973, p. 173) nor Murina (1975b, p. 1748, 1752), however, considers that *Paraspidosiphon* is justified at the generic level, each preferring to regard *Aspidosiphon* as consisting of two subgenera, *Aspidosiphon* (*sensu stricto*) and *Paraspidosiphon*.

Centrosiphon (Shipley, 1903), which Stephen and Edmonds (1972) included in this family, is being omitted because it now seems to me that *C. herdmani*, the type of the genus, is a golfingiid. The taxonomic position of the species is, however, still uncertain.

The tentacular arrangement in *Aspidosiphon* and *Paraspidosiphon* as stated by Stephen and Edmonds (1972, p. 217) is now known to be wrong, Gibbs (1977) pointing out that the tentacles lie in a near ring dorsal to the mouth, as in *Phascolosoma* (see remarks on p. 8). I am not certain how the tentacles are arranged in *Cloeosiphon* and *Lithacrosiphon*.

Genus **Aspidosiphon** Diesing

Aspidosiphon Diesing, 1851, p. 67 (in part); Stephen, 1964, p. 457.

Description: Anal and caudal shields usually prominent and longitudinal muscles of body wall continuous and not separated into bundles. Anal shield may be circular, elliptical or horseshoe shaped, darker in colour than the trunk, with its surface sometimes furrowed, grooved or covered with hard, irregularly arranged granules. Caudal shield may be flat, hemispherical, conical or truncate; it may or may not be furrowed or grooved. Sometimes the caudal shield is not strongly developed. Introvert arises from the ventral side of the anterior shield. Tentacles digitiform and arranged in a horseshoe-shaped ring dorsal to mouth (see foot-note on p. 8). One or two retractors. Two nephridia. Contractile vessel simple.

Type species: *Aspidosiphon muelleri* Diesing, 1851.

KEY TO SPECIES OF *ASPIDOSIPHON* FOUND IN AUSTRALIA

1. Introvert hooks—all with single points 2
   Introvert hooks—some or all with two points 4
2. Hooks with long, bent points ..... **A. exhaustus* (p. 46)
   Hooks without long, bent points 3
3. A number of knobby papillae on anterior part of anal shield modified to form spine-like structure . *A. inquilinus* (p. 47)
   No spine-like structures on anal shield; tendency for circular musculature of body wall to be striated . *A. gracilis* (p. 46)
4. Surface of anterior shield furrowed or ribbed 5
   Surface of anterior shield not furrowed
   A. elegans elegans (p. 44)
5. Anterior shield with about 12 furrows, posterior shield with weaker striations (well known inhabitant of solitary corals) ..... *A. jukesii* (p. 49)
   Anterior shield with 5-6 furrows, posterior shield with 24-25 ..... *A. hartmeyeri* (p. 47)

A. elegans elegans and *A. gracilis* inhabit coral reefs and *A. hartmeyeri* limestone reefs. *A. jukesii* lives in the solitary coral *Heteropsammia* and *A. inquilinus* inhabits the shells of *Dentalium* and other molluscs.

Aspidosiphon elegans elegans (Chamisso and Eysenhardt)

(Figs. 71-76)

Sternapsis elegans Chamisso and Eysenhardt, 1821, p. 351 pl. 24, figs. 5a-e.

Aspidosiphon elegans Grübe 1868a, pp. 645-647, pl. 8, fig. 5·5a-b; Selenka and de Man, 1883, pp. 124-6, pl. 1, figs. 10-10a, pl. 14, figs. 205-208; Sato, 1935, p. 316; Sato, 1939, p. 426-7.

Aspidosiphon exilis Sluiter, 1886, p. 497, pl. 3, figs. 11-12.

Location of type: Not known to author; type locality, "small islands of the Pacific Ocean".

Description: Slender, delicate, pale to straw coloured and coral dwelling. Trunk more or less cylindrical, 8-14 mm long and 1·7-2·8 mm wide, thin walled and fragile and sometimes slightly curved so that ventral is slightly shorter than dorsal side. Longitudinal musculature continuous.

Anal shield prominent, elliptical, dark brown (although golden around edges) and usually warty; consists of brown polygonal plates placed closely together and usually lacking furrows (although edges may be ridged to some extent). Caudal shield more weakly developed and sometimes almost insignificant, usually hemispherical with chitinous structures around its periphery; furrows, if present are only marginal.

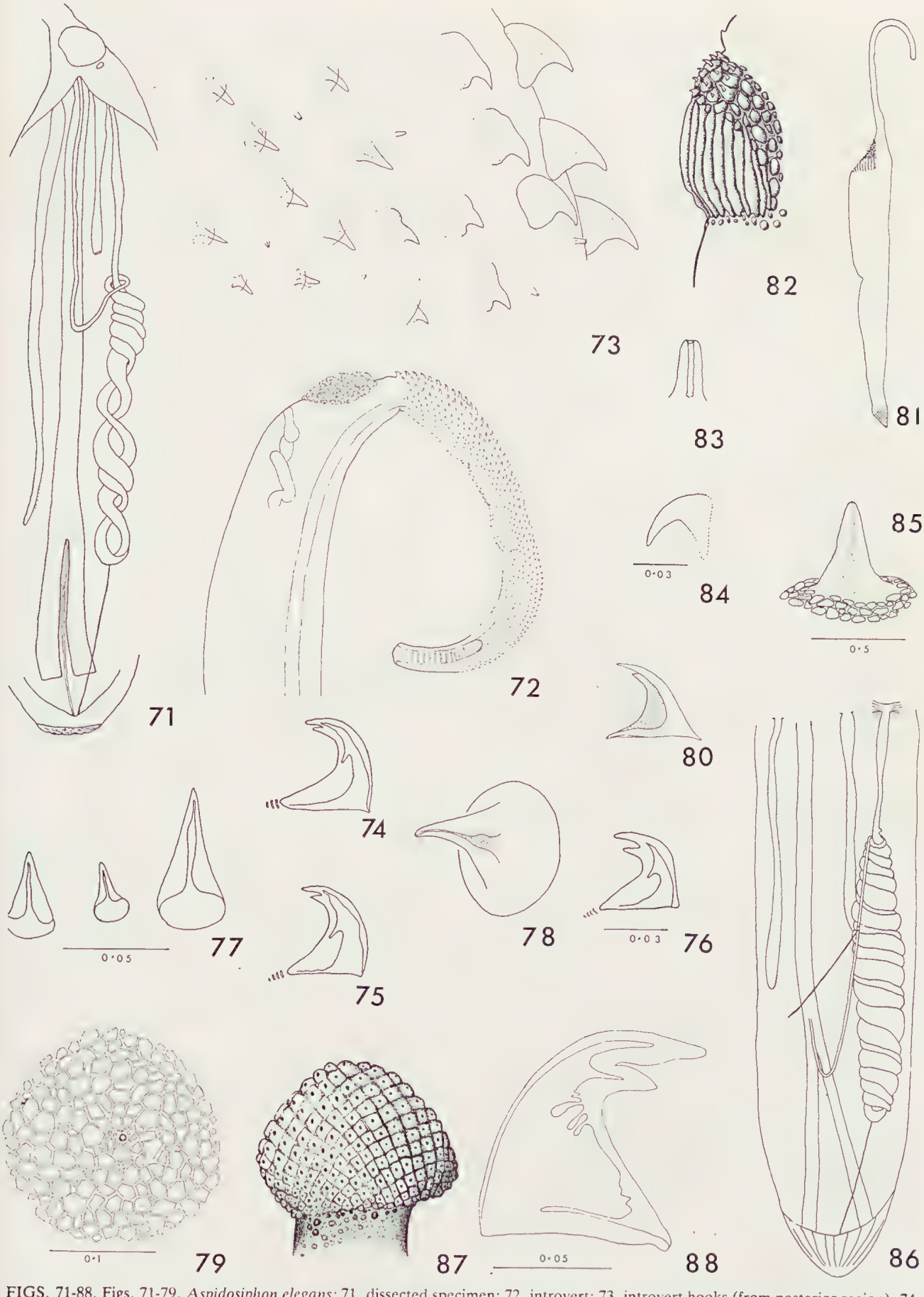
Papillae on trunk flat and usually restricted to (1) a narrow region just posterior to anal shield and (2) a narrow region at posterior of trunk, consisting of aggregates of flat polygonal plates grouped around a small circular opening. Caudal shield of some specimens consists of structures resembling closely set papillae.

Introvert of fixed specimens about as long as or a little longer than trunk, slender, thin walled, arising ventrally to anal shield and bearing anteriorly a few tentacular-like structures; armed with 15-30 rows of small dark hooks with two points. Clear area inside hook usually possesses a small, backwardly directed tongue or extension (slight variations of the angle at which the hook lies on a slide can cause considerable differences in its appearance). Hooks in most posterior rows of some specimens are smaller and lack internal markings—whether they are developing hooks or not is not known.

Dark, single pointed, closely set spines of varying size and shape lie on introvert posterior to hooks, their field extending to its base; spines (1) are larger and more closely set on dorsal surface of introvert and (2) become larger the more posteriorly they are placed. In some specimens, where spination is heavy, spines arise from strong bases or rooting processes and clearly possess a central, tubular canal.

Retractor muscle, arising from body wall well in front of caudal shield, consists of two short roots. Intestine loosely wound and frail. Rectum long and lacking a caecum. No intestinal fasteners observed. Two thin and delicate nephridia, about half as long as trunk, are fixed to body wall for most of their length. Spindle muscle fixed posteriorly.

Systematics and discussion: There is a group of aspidosiphonids in which the longitudinal musculature is continuous; which possess introvert hooks with two points, well developed introvert spines with single points (often with strong rooting processes) and which bear small truncated papillae on the introvert. They possess few or no papillae on the trunk except near the anal and caudal shields and the papillae are flat and consist of polygonal plates. They possess a single retractor muscle that arises from two roots which are fastened to the body wall well anterior to the caudal shield. Their nephridia are about half as long as the trunk and are fixed to the body wall for most of their length. Some of these species are *Aspidosiphon spinalis* Ikeda, 1904 (from Japan and Jaluit Is.), *A. spinosus* Sluiter, 1902 (from Indonesia). *A. homomyarius* Johnson, 1964 (from west coast of India), *A. exilis* Sluiter, 1886 (from Indonesia), *A. carolinus* Sato, 1935 (from West Caroline Is.), *A. brocki* Augener, 1903 (from Malaya), *A. elegans elegans* (Chamisso and Eysenhardt, 1821 (from Pacific Is., Philippines and the red Sea) and *A. elegans yapensis* Sato, 1935 (from West Caroline Is.).



FIGS. 71-88. Figs. 71-79, *Aspidosiphon elegans;* 71, dissected specimen; 72, introvert; 73, introvert hooks (from posterior region); 74-75, introvert hooks with two points; 76, hook from *Aspidosiphon exilis* Sluiter; 77, spines from introvert; 78, larger spine from posterior region of introvert; 79, papilla fron anterior region of trunk (Figs. 74, 75 & 77 to same scale). Fig. 80, *Aspidosiphon hartmeyeri;* introvert hook (after Fischer). Figs. 80-86, *Aspidosiphon inquilinus;* 81, entire animal; 82, anal shield; 83, small papilla from introvert; 84, single pointed hook from introvert; 85, spiny papilla from anal shield; 86, dissected specimen. Figs. 87-88, *Cloeosiphon aspergillus;* 87, anterior cap; 88, introvert hook.

The first of these to be described was *A. elegans*. The description of Chamisso and Eysenhardt is very brief and deals with external features only. Their figures, however, show that their specimens are those of an *Aspidosiphon* with an anal and caudal shield, an introvert which arises ventral to the trunk, that the introvert is armed wth hooks and spines, the latter increasing in size the more posteriorly they lie. Their specimens were collected "on the low-lying or small (= humiles) islands of the Pacific Ocean, in places that are washed by the tides, and boring in coral rocks, apparently by means of their shield (= scutum)". Grübe's (1868) description of *A. elegans* from specimens from the Red Sea is fuller. The anterior shield is furrowed to some extent, the spines on the introvert are largest posteriorly and the papillae on the trunk are more prominent must posterior to the anal shield. His drawing of the bilobed hooks, however, is difficult to follow. The most detailed description of the species is that of Selenka and de Man 1883, their specimens having been collected from the Philippines and the Red Sea, the latter specimens showing some differences from those from the Philippines.

The specimens which I am describing from the Pacific Ocean (Hawaii, Solomons, New Hebrides and the Great Barrier Reef) resemble *A. elegans* in the following respects (1) the presence of double-pointed hooks with internal marking like those of *A. elegans* (2) flat papillae composed of polygonal plates (3) the spination of the introvert posterior to the hooks, the spines being largest on the dorsal surface and at the base of the introvert (4) the presence of a single retractor which stems from two roots attached to the posterior third of the body wall (5) the presence of two nephridia attached for most of their length.

Selenka's specimens, however possessed a caecum and a fastening muscle. Nevertheless, I am regarding my specimens as *A. elegans*.

An examination of Sluiter's specimens of *A. exilis* from (1) Siboga Stn. 172 (2 spec.) labelled "type" and (2) Diuzend Eil (Tausend Is.) (1 spec.) shows that they are identical with what I am regarding as *A. elegans*. The hooks, spines and papillae correspond in all respects. Consequently I have placed *A. exilis* Sluiter, 1886 in the synonymy of *A. elegans*. *A. homomyarius* Johnson, 1964, according to his description, is also very closely related to *A. elegans*.

A. elegans seem to have been found only in formations of coral.

No previous Australian record.

Distribution: (1) in Australia: Queensland at Three Is. and Lizard Is. (Gt. Barrier Reef).

(2) elsewhere: Pacific Is. (Chamisso and Eysenhardt, 1821), West Caroline Is. (Sato, 1935), Japan (Sato, 1939); Hawaii (in the present paper); Funafuti (Shipley, 1898); Indonesia (Sluiter, 1886); Philippines (Selenka & de Man, 1883); Gulf of Manaar (Gravely, 1927), Mauritius (Wesenberg-Lund, 1959b); Red Sea (Grübe, 1868, Herubel, 1904, Fischer, 1914, Wesenberg-Lund, 1957).

Specimens examined and localities: Queensland —Great Barrier Reef at Three Is. (4) coll. Dr. P. E. Gibbs SAM E1265, at Lizard Is. (5) coll. P. Wearne, at Heron Is. (1) coll. R. Reichelt.

The description of the species given above was based on these specimens and about 20 more from Hawaii.

*Aspidosiphon exhaustus Sluiter

Aspidosiphon exhaustus Sluiter 1912, pp. 20-21, pl. 1, fig. 11.; Murina, 1972, pp. 295-298, 1977, p. 42-43, fig. 98.

Location of type: ? Zoological Museum, Amsterdam; specimen from off Morocco (36° 42'N, 8° 40' 3C'W at 310-749 m).

Description (based on Sluiter 1912): Trunk 17 mm long and 2 mm wide. Introvert about as long as trunk and armed with numerous rows of very small, transparent hooks with long bent points. Anal shield oval and marked posteriorly with 12 radial furrows. Caudal shield with 10 furrows. Two retractor muscles, attached to caudal shield, join to form a single muscle. Two long nephridia attached to trunk for most of their length.

Murina (1972) gives the length of her Australian specimen as 15 mm and reports the presence of 20 furrows on the anterior shield.

Australian record: off coast of N.S.W., (33° 34' 5" S, 152° 06' 5" E) at depth of 425 m. 1 specimen: Murina 1972, pp. 295-298.

Distribution: (1) in Australia: off coast of New South Wales.

(2) elsewhere: off Morocco (Sluiter, 1912); Pacific Ocean at 27° 13' S, 109° 25' W and Atlantic Ocean at 5° S, 11° E (Murina, 1972).

Aspisosiphon gracilis Baird

(Figs 94-96)

Pseudaspidosiphon gracile Baird 1868, p. 103, pl. 10, figs 1, 1a.

Aspidosiphon gracilis: Selenka and de Man 1883, pp. 122-123, fig. 22, 209-213; Rice and Stephen 1970, p. 69.

Location of type: Natural History Museum, London, reg. no. 43.5.15. 58a-b; specimens from Philippine Is.

Description: Specimen long and slender. Trunk about 45 mm long and 2·5-3·0 mm wide, curved to resemble a horse-shoe, grey and bearing dark brown, hemispherical papillae which contrast with lighter coloured background of trunk. Because the darker papillae and the lighter areas of the trunk tend to lie in short longitudinal rows the trunk appears mottled.

Anal shield with 10 almost complete longitudinal furrows. Caudal shield sharply conical and with about 28 complete and a few incomplete radial furrows. Brown papillae, consisting of numerous closely set polygonal plates, are 0·10-0·22 mm in diameter and at their summit there is a white pore. Similar but smaller papillae lie on posterior surface of introvert and on body wall between radial furrows of caudal shield.

Introvert, light yellow in colour, about 40 mm long and 1·4 mm wide arising ventrally to anal shield; armed with small single pointed hooks, with width of base greater than height. Small conical papillae also present on surface. Prominent spines (fig. 00) scattered over much of introvert. A tendency for the musculature to be striated circularly is evident in the dissected specimen. Baird comments on a similar condition in his specimens, "Corpus gracile, – – – – striis circularibus cinctum, – – –."

Two retractors arise from body wall near posterior extremity of trunk. Alimentary canal very long and much coiled. Contractile vessel poorly developed. Neither an intestinal fastener nor caecum found. Two very long, free, almost black nephridia, nearly as long as trunk, arise at about same level as anus.

Systematic position: This specimen is one of the few which have been recorded and described.

No previous Australian record.

Distribution: (1) in Australia: Queensland at Low Is.

(2) elsewhere: Philippine Is.

Specimen examined and locality: Queensland —Low Is. (1) coll. Dr. P. E. Gibbs, SAM E1254.

Aspidosiphon hartmeyeri Fischer

(Fig. 80)

Aspidosiphon hartmeyeri Fischer, 1919a, p. 277; 1927, p. 204; Edmonds, 1956 p. 306, fig. 18; Cutler, 1977, pp. 147-148.

Location of type: Not known to author; type locality, Shark Bay, Western Australia.

Description: Trunk as long as 20 mm. Introvert about same length. Shields darker than trunk and composed of thick polygonal plates. Anterior shield with 5-6 furrows, posterior with 24-25. Introvert with hooks of two points and more posteriorly irregularly arranged spines. Tentacles 6-8. One retractor muscle with two long roots fixed near caudal shield. Strong spindle muscle fixed posteriorly. Nephridia more than half length of trunk, free for most of their length and opening just posterior to anal aperature. Longitudinal musculature continuous; circular muscles tend to form anastomosing bundles, most readily noticed in dissected animals. This probably accounts for the "Querstreifung" noticed by Fischer (1919). Two eyespots. Edmonds (1956) reports an intestinal fastener to last intestinal whorl and a caecum.

Systematic position: Although described from Australia the species is not well known in this country. The hooks of Edmonds' (1956) specimens are slightly different from those of Fischer. The species needs redescription from specimens collected at the type locality. I have used Fischer's figure of the hook.

Previous Australian records: Western Australia—Shark Bay (Fischer, 1919a); Rottnest Is. (Edmonds, 1956). South Australia—Great Australian Bight (37° 18' S, 138° 43' E at 795 m) (Cutler, 1977).

Distribution: (1) in Australia: Western Australia at Shark Bay and Rottnest Is.; off coast of South Australia.

(2) elsewhere: West African coast (Wesenberg-Lund, 1959a); Cuba (Murina, 1967).

Specimen examined and locality: Western Australia—Rottnest Is., (1) SAM E1250.

Aspidosiphon inquilinus Sluiter

(Figs. 81-87, 89)

Aspidosiphon inquilinus Sluiter, 1902, p. 29-30, pl. 2, figs 21-22.

Location of type: Zoological Museum, Amsterdam; specimen from Siboga Stn. 282 (8° 25·2' S, 127° 18' E, 27-54 m). In shell of *Dentalium* sp.

Description: Description based on three specimens found in shells of *Dentalium* sp. and one from shell of a nassariid mollusc. Specimens from *Dentalium* small, slender, sub-cylindrical becoming more slender posteriorly. Trunk 4-8 mm long, 0·7-1·0 mm wide anteriorly and 0·5-0·7 mm posteriorly Colour off-white to pale yellow. Specimen from gastropod coiled.

Anal and caudal shields strongly differentiated from trunk and brown to dark brown in colour. Anal shield subtriangular with about 14-18 longitudinal furrows, surmounted by hard, warty and knobby papillae which are usually arranged so as to form approximately 3-5 transverse furrows. A feature of the shield is that 6-15 of the most anterior placed papillae are modified to form spine-like structures. Caudal shield conical with about 18 complete and incomplete furrows.

Introvert (not completely evaginated in any specimen) about as long as trunk or little longer, slender and about 0·5 mm wide. No tentacles observed in a dissected specimen but this point needs checking. Anteriorly introvert bears 25 or more rows of very small single-pointed hooks about 0·015-0·020 mm tall and wide. Between rows of hooks and over most of surface of introvert are numerous, small, tubular papillae or glands about 0·02 mm tall. Spines are also distributed over surface of introvert.

Papillae or skin bodies on trunk mostly elliptical in shape. Longitudinal musculature continuous. Introvert retractor single for over half its length but arising from two shorter roots attached to or near caudal shield. Oesophagus emerges from between roots of retractor and loops up; single fastening muscle attached to it. Spindle muscle fixed posteriorly and a wing muscle present. Rectum with small conical caecum. Two free nephridia, about half as long as trunk, attached to body wall at about level of anus.

Systematic position: I have compared these with the holotype of *A. inquilinus* Sluiter, described from a single specimen found in a *Dentalium* shell in the Timor Sea (8° 25' S, 127° 18' E) and consider them to be the same. The holotype is cylindrical and its shields are well defined. The anterior shield, however, is obliquely inclined to the longitudinal axis of the trunk but in the opposite way to the usual, its anterior region is tucked in and slopes down to the introvert (the effect is produced by the contraction of the longitudinal musculature nearby in the trunk). One important point, not mentioned by Sluiter, is that a few of the knob-like papillae which comprise the anterior part of the anal shield are modified to form sharply pointed hooks or spines which are obscured to some extent in the holotype by the introvert. The introvert retractor of the holotype (a dissected specimen) is single for well over half its length and arises from two shorter roots fixed to the trunk near the caudal shield. The specimens from Moreton Bay are smaller and so are their hooks. They possess a caecum and an intestinal fastener, neither of which is mention in the type description. Unfortunately, owing to the frail and damaged condition of the gut, it is difficult to say whether the structures are now present in the holotype or ever were.

FIG. 89. *Aspidosiphon inquilinus*, (two specimens from Moreton Bay, Queensland; one in shell of *Dentalium*).

The Australian specimens are also closely related to *Aspidosiphon kovaleskii* Murina, 1964a collected from the shells of *Dentalium* sp. in the Adriatic and Aegean Seas. They differ, however, from *A. kovaleskii* in that (1) externally they possess spines and tubular papillae on the introvert and (2) internally they possess a caecum, only one fastening muscle and nephridia which are free and not attached.

Murina, 1972, p. 295 reported *A. exhaustus* Sluiter, 1912 living in the dead shells of gastropods (*Mitra* sp.) from the coasts of New South Wales and Western Australia. *A. exhaustus*, however lacks the spine-like structures on its anal shield and is consequently thought to be different.

No previous Australian record.

Distribution: (1) in Australia: Moreton Bay, Queensland.

(2) elsewhere: Timor Sea (Siboga Stn. 282).

Specimens examined and localities: Three specimens from shells of *Dentalium* sp. collected during Moreton Bay Survey, Queensland by Stephen Cook

(Dept. of Zoology, Univ. of Queensland) at Stn. 28 in March, 1973. Two were dissected. One specimen also collected from shell of a nassariid at same locality; depth 10 m. SAM E1266.

Aspidosiphon jukesii Baird

(Figs. 97-99)

Aspidosiphon jukesii Baird, 1873, p. 97; Rice and Stephen, 1970, pp. 68-69.

Aspidosiphon corallicola Sluiter, 1902, pp. 19-25.

Location of type: Nat. Hist. Museum, London: reg. no. 1965.25.3; specimen from Lee Sandbanks (Great Barrier Reef), Queensland.

Description: All the specimens had been removed from the coral and fixed and the introvert was retracted except in two, where it was partly extended. Trunk either curved in a circle or coiled, with an estimated maximum length of 28 mm and maximum width of 5-8 mm. Anterior shield almost horseshoe-shaped, very dark in colour and warty, with radial furrows well developed on dorsal half. Furrows on ventral side of shield less strongly marked and run almost at right angles to radial ones. Anus prominent dorsally, just below anal shield. Posterior shield conical to hemispherical, light yellow and with radial furrows. Both shields correspond very closely to those of *A. jukesii* shown in figs. 21-23 of Rice and Stephen (1970).

Introvert (in retracted state) with length about three quarters that of trunk and bearing (1) small, doubly pointed hooks, (2) spines of variable size and (3) small, slender, sub-conical papillae which arise from hemispherical base. Papillae well developed on anterior and posterior fourth of trunk. A strong introvert retractor, dividing posteriorly into two stout roots, attached to body wall near caudal shield.

Longitudinal musculature continuous. Rectum long; without caecum and fastening muscle. Spindle muscle attached posteriorly. Nephridia slender, about half to three quarters as long as trunk and attached for about half of their length. Elliptical to spherical eggs 0·12-0·16 mm in diameter.

Systematics and remarks: These specimens from Queensland correspond very closely to Baird's *A. jukesii* as redescribed by Rice and Stephen (1970) and *A. corallicola* Sluiter 1902. Baird's specimens were obtained from Lee Sandbanks (Great Barrier Reef) and Sluiter's from solitary corals, including *Heteropsammia michelini* from Indonesia. Through the kindness of the authorities of the Zoological Museum of Amsterdam I have been able to compare my specimens with those of Sluiter (reg. no. V.Si.7.). The examination confirms the conclusion of Rice and Stephen (1970), that *A. jukesii* and *A. corallicola* are synonymous. The species is well-illustrated in Rice and Stephen, 1970.

The association between the solitary corals *Heteropsammia* and *Heterocyathus* and the sipunculan *A. jukesii* was first reported by Edwards and Haime, 1848a and 1848b and has been redescribed by a number of writers, listed by Rice (1976). In a discussion on the matter Rice says, "The *Aspidosiphon* inhabits a spiral cavity in the base of the coral and, through an opening of the cavity on the under surface of the coral, the sipunculan extends its introvert into the surrounding substratum pulling the coral about as it probes and feeds in the sand. Through this association, the sipunculan is provided with a protective habitat and, by movements of the sipunculan, the coral is maintained in an upright position on the surface of the substratum and transported about to different feeding areas." The developmental history of the association has also been carefully studied. According to Rice, "The juvenile *Aspidosiphon*, when 1 mm or less in length, enters an empty gastropod shell, usually a small *Cerithium*. A coral planula settles on the shell, overgrowing and eventually enclosing it. Only those planulae settling on shells occupied by sipunculans have any chance of survival. Growth of the sipunculan and the coral are well synchronized, the sipunculan actively enlarging its cavity as a spiral tube in the base of the growing coral while maintaining an opening of the tube on the underside of the coral".

Previous Australian record: Queensland: Baird (1873); Goreau and Yonge (1968).

Distribution: (1) in Australia: Queensland at Heron Is. and Lizard Is.

(2) elsewhere: Malaysia, Gulf of Manaar, Zanzibar and Madagascar.

Specimens examined and localities: Queensland —Lizard Is., (20) in the solitary coral *Heteropsammia michelini;* coll. D. Fisk (Dept. of Botany, Univ. of Queensland) SAM E1255 and E1256; Wistari Reef, Heron Is., "in solitary coral" AMS W5620.

Genus **Paraspidosiphon** Stephen

Paraspidosiphon Stephen, 1964, p. 457; Stephen & Edmonds, 1972, p. 237.

Description: Sipunculans with anal and caudal shields and with characters similar to those of *Aspidosiphon* Diesing but differing in that the longitudinal musculature of body wall is grouped into bands which may anastomose, sometimes considerably. Introvert, arising from ventral side of trunk, may be armed with hooks or spines, often

both. Tentacles as in *Aspidosiphon*. Introvert retractors one or two short roots. Spindle muscle attached posteriorly.

Type species: *Paraspidosiphon steenstrupii* (Diesing, 1859).

Remarks: Stephen considered that the condition of the longitudinal musculature warranted the separation of *Paraspidosiphon* from *Aspidosiphon* and *Fisherana* from *Phascolosoma*. Not everybody agrees with this. Both Cutler (1973) and Murina (1975b) consider that *Paraspidosiphon* warrants the status only of a subgenus. The genus contains about 25-30 species, most of which live in burrows in limestone or coral reefs.

Specimens of *Paraspidosiphon klunzingeri* and *P. steenstrupii* reported from Low Is. by Edmonds (1956) are now being referred to other species, the former to *P. johnstoni* n.sp. and the latter to *P. formosanus* (Sato).

KEY TO AUSTRALIAN SPECIES OF *PARASPIDOSIPHON*

1. Introvert hooks with a single point 2
   Introvert hooks with two points 3
2. Numerous rectal appendages present ..... *P. cumingii* (p.50)
   Numerous rectal appendages absent . *P. johnstoni* n.sp. (p.51)
3. Introvert hooks with a thin, posteriorly directed, tongue-like extension of clear area ..... *P. steenstrupii* (p.51)
   Introvert without tongue-like extension of clear area *P. formosanus* (p.50)

***Paraspidosiphon cumingii** (Baird)

Aspidosiphon cumingii Baird, 1868, p. 102; Selenka & de Man, 1883, pp. 113-115, pl. 13, figs 183-186; Rice & Stephen, 1970, p. 67.

Paraspidosiphon cumingii: Stephen & Edmonds, 1972, pp. 243-244.

Location of type: Nat. Hist. Museum, London: specimen from Philippines.

Remarks: This species is often reported from tropical and near tropical localities and is allied to *P. klunzingeri*. The introvert, however, is armed with single-pointed hooks and spines. The anterior shield has 12-13 furrows around its margin and the caudal has 30 of which only about 12-13 reach the centre of the structure. There are 27-28 longitudinal muscles anteriorly and 32-34 posteriorly. According to Selenka the posterior region of the rectum is thickly bordered with long, tufted villi ("Das letzte Ende des Mastdarmes ist dicht mit langen zottenartigen Gebilden besetzt"). There is one broad retractor which spans about 19 muscle bands; sometimes the retractor may split into as many as four roots. Two nephridia, attached for about two-fifths of their length extend to the posterior of the trunk. Selenka states that it has a strong fixing muscle.

Australian record: Low Is., Queensland (Monro, 1931).

Distribution: (1) in Australia: Low Is., Queensland.

(2) elsewhere: West Indies, Red Sea, Philippines, Zanzibar, Malaysia.

Paraspidosiphon formosanus (Sato)

(Figs 90, 92, 93)

Aspidosiphon formosanus Sato, 1939, pp. 421-424, text figs 55-57, pl. 21, fig. 23.

Paraspidosiphon formosanus: Stephen & Edmonds, 1972, p. 245; Edmonds, 1971, pp. 144-145.

Aspidosiphon steenstrupii: Edmonds, 1956, p. 307, fig 19.

Location of type: Not known to author; specimen from Sinko, Taiwan (Formosa).

Description: Specimens yellow to pink and tend to be slender. Trunk of largest 30-32 mm long and 2·5-4·0 mm wide and tending to curve inwards on ventral side. Anal shield elliptical, dark brown to black and composed of small knobby wartlike bodies to which white calcareous material may be attached; without furrows, although its periphery may be ridged. Caudal shield light brown, rounded, or conical and sometimes only weakly developed; if conical, weak radial furrows may be present but if rounded they do not appear. Papillae on trunk most prominent on surface adjacent to anal shield and are composed of small, closely packed, polygonal to rounded platelets; diameter of largest papillae 0·45 mm. Papillae near anal shield usually separated by grooves, which themselves are covered with small polygonal platelets. Papillae on mid-trunk region usually smaller, more rounded and scattered or even absent in some specimens. Papillae on posterior trunk larger and more prominent.

Introvert of retracted specimens about half as long as trunk; of expanded ones nearly twice as long. A few stoutly digitiform tentacles protrude adjacent to mouth in one specimen; surface of introvert just posterior to mouth is smooth and collarlike. Introvert armed with many rows of hooks with two points and spines with one point. Small truncated to cylindrical papillae lie between rows of hooks and among spines. Secondary or minor tooth of hooks tends to curve more strongly than primary one. Internally, clear area which at base of hook is half to three quarters as wide as hook, gradually tapers towards apex of hook. None of the mounted hooks show the posteriorly directed, tongue-like extension of the clear area like that shown for *P. steenstrupii* in fig. 192 of Selenka & de Man (1883) nor the

FIG. 90. *Paraspidosiphon formosanus*, (specimen from Queensland).

indentation on the right side of the clear area shown in fig. 59 of Sato (1939). Although all spines are single pointed, their shape varies considerably; some closely resemble single pointed hooks, some are more tetrahedral and others more slender and pointed. The variation is much like that shown for *P. grandis* in fig. 49 of Sato (1939).

Two introvert retractors, arising from muscles 2-5, 2-6, or 3-7 a short distance in front of caudal shield, remain separate for about one to two thirds of length of trunk before fusing to form a stout, single retractor. Oesophagus, carrying a simple contractile vessel, is attached to single retractor. Intestine with about 22 double spirals and rectum with a caecum. Spindle muscle strong and fixed posteriorly. No fixing muscle. Nephridia long (extending to posterior extremity of trunk), fixed for about half their length and opening at about same level or just posterior to that of anus. Brain simple with two eyespots.

Sytematics: Although the internal anatomy is very much like that of *P. steenstrupii* (Diesing), the hooks of these specimens lack the thin tongue-like extension of the clear area shown in fig. 192 of Selenka & de Man (1883) and in pl. 1 fig. 4 of Augener (1903). The shape of the hooks is close to that of *P. ambonensis* (Augener, 1903). The shields of the latter, however, are furrowed. The specimens are also close to *P. makoensis* (Sato, 1939) and *P. formosanus* (Sato, 1939), two species which themselves are allied. The shape of the hooks of the Australian specimens corresponds to those of the latter.

Edmonds (1956, p. 307 and fig. 19) described some specimens from Heron Is., Queensland as *P. steenstrupii*. I now think that this identification was wrong. The hooks, as shown in fig. 19, are like those of the specimens which I am now describing from Magnetic Is. and lack the tongue-like extension of the clear areas as shown by Selenka & de Man and Augener. Consequently the record of 1956 is now placed in the synonymy of *P. formosanus*.

No previous Australian record.

Distribution: (1) in Australia: Queensland.

(2) elsewhere: Formosa, Guam.

Specimens examined and localities: Queensland —Low Is., (2) SAM E1275; Magnetic Is. (2) SAM E1277.

***Paraspidosiphon steenstrupii** (Diesing)

Aspidosiphon steenstrupii Diesing, 1859, p. 767, pl. 2, figs 1-6; Selenka & de Man, 1883, pp. 116-118, pl. 1, figs 12-13, pl. 13, figs 190-192.

Paraspidosiphon steenstrupii: Stephen & Edmonds, 1972, p. 254.

Location of type: Not known by author; specimen from St. Thomas.

Remarks: This species differs from *P. formosanus* in possessing introvert hooks in which the clear area carries a thin tongue-like extension, much like that of *Aspidosiphon elegans*. Edmonds (1956, p. 307, fig. 19) described some specimens from Low Is. as *P. steenstrupii*. I now think that they should have been called *P. formosanus* and am transferring the 1956 record to the synonymy of *P. formosanus*. *P. steenstrupii* has often been recorded from tropical and subtropical seas.

Australian record: Low Is., Queensland (Monro, 1931).

Distribution: (1) in Australia: Low Is., Queensland.

(2) elsewhere: West Indies; Brazil; Mauritius; Red Sea; Laccadive Is.; Japan; Philippines; New Hebrides; Indo China; Loyalty Is., and Cuba.

Paraspidosiphon johnstoni n. sp.

(Figs. 91, 100-102)

Aspidosiphon klunzingeri: Monro, 1931, p. 34; Edmonds, 1956, pp. 308-9, fig. 20, pl. 3, fig. 1.

Location of type: Australian Museum, Sydney; specimen from coral in Moreton Bay, Queensland (coll. Prof. T. H. Johnston).

Description: Trunk usually cylindrical, sometimes curved ventrally, 20-45 mm long and 3-5 mm wide. Introvert, arising ventrally from trunk, is in fixed specimens about as long as or a little longer than trunk and armed anteriorly with very numerous (165) rows of single pointed hooks with a stout base and a curved tip. Hooks in posterior rows noticeably smaller than those in anterior rows. Posterior to rows of hooks is a narrow zone of scattered, single pointed "hooks" or "spines", closely resembling those more anteriorly, but which are much smaller and lack fine internal markings. Posterior part of introvert with out spines. Small, truncated to subconical papillae lie between rows of hooks and on surface of trunk. Tentacles short, few and finger-like lying in a part ring dorsal to mouth as in *Phascolosoma*.

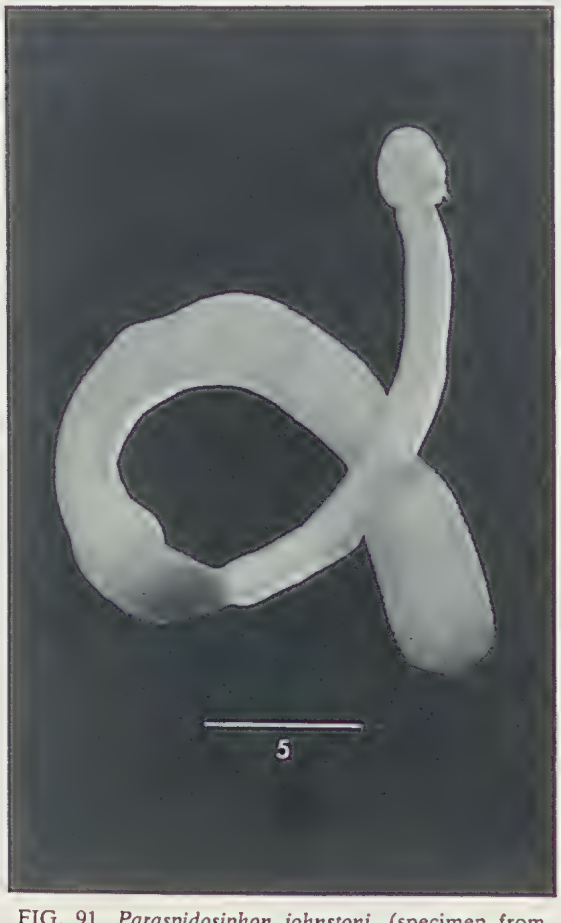


FIG. 91. *Paraspidosiphon johnstoni*, (specimen from Queensland).

Shields dark gold to red brown in colour, wartlike in texture and appearance and prominent. Anal shield fan-like, lying obliquely to trunk and possessing 10-16 complete and incomplete furrows which radiate dorso-ventrally like ribs of a fan. Posterior shield conical, often carrying a rim at junction with trunk and possessing 22-28 complete and incomplete radial furrows. Furrows of both shields may extend over lateral margins of shield, thus making surface of trunk joining shields appear furrowed. Furrows correspond approximately to tissue between longitudinal muscles.

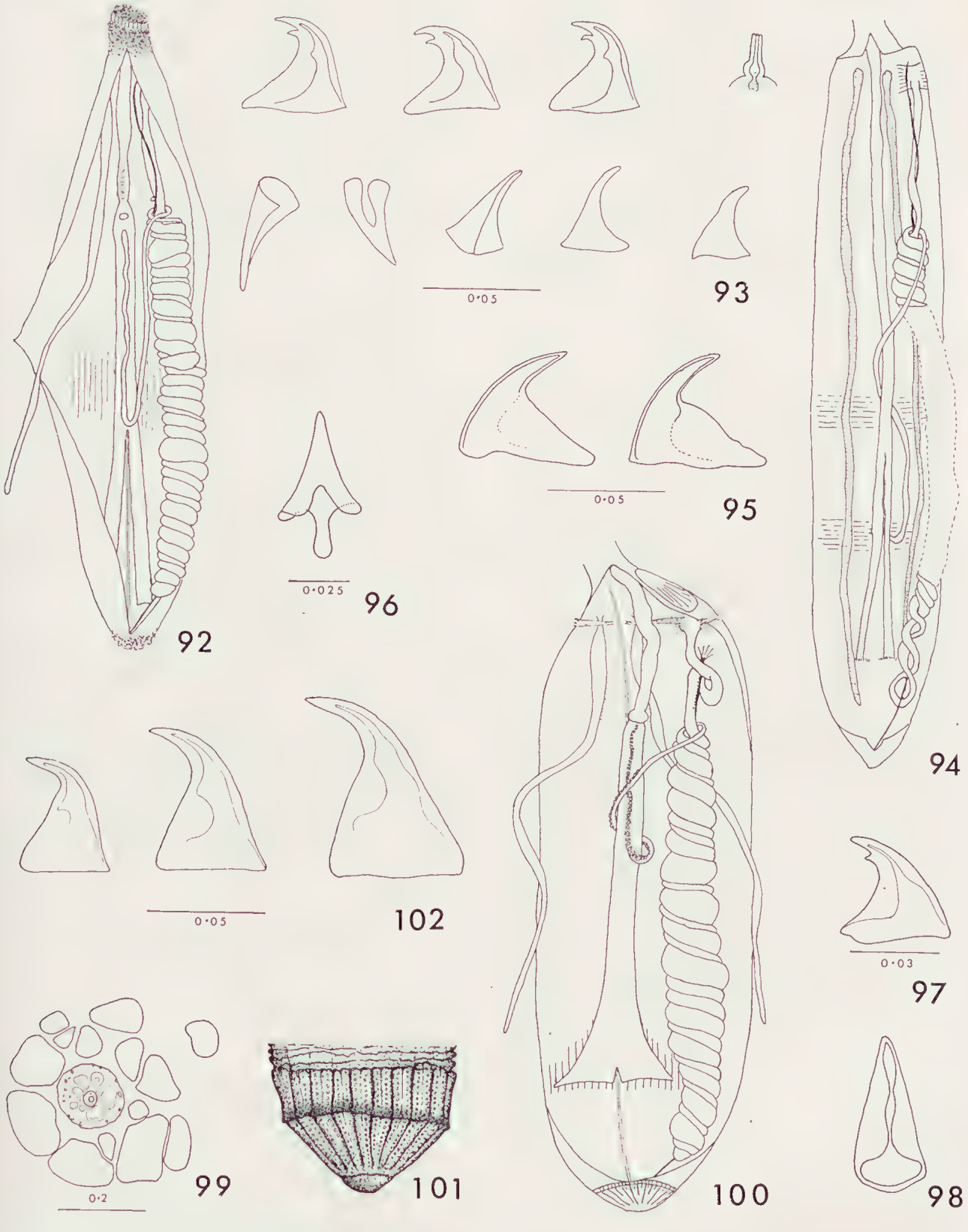
Body wall thick and longitudinal musculature in 25-32 anastomosing bundles. Circular musculature tends to form fascicles. Retractor muscle very strong, arising from two short roots each of which spans muscles 1-8, 2-7, 2-6 and 1-9 well in front of caudal shield. Oesophagus attached to retractor muscle for part length of latter. Intestinal spirals numerous and extend to posterior of trunk. Nephridia tubular, about three quarters as long as trunk and fixed for anterior quarter. No intestinal fastener and no rectal caecum. Wing muscle strong; in addition two strong muscles are attached to rectum near anus and run transversally across body wall to muscle 1 or 2 on each side of nerve cord. Spindle muscle stout, arising anteriorly from body wall under rectum, and fixed posteriorly. A strand of fine tissue connects rectum and body wall in some specimens. Contractile vessel without villi.

Systematic position: The specimens closely resemble *P. klunzingeri* (Selenka & de Man) in the shape and marking of the introvert hooks and in internal anatomy. They differ from it, however, in that (1) no rectal sac bearing numerous lobes on both sides is present ("am Rectum sitz ein grosser, an beiden Seiten vielfach gelappter Blindsack") (2) they lack a well defined region of introvert spines and to a less extent (3) the spindle muscle arises from the body wall under the rectum and not in front of the anus ("Ein Spindelmuskel nimmt unmittelbar vor dem After seinen Anfang").

The Australian specimens also resemble *P. pachydermatus* (Wesenberg & Lund, 1937), *P. grandis* (Sato, 1939) and *P. cumingii* (Baird, 1868). They differ in that the last three species possess rectal appendages as clearly shown in Wesenberg-Lund 1937, fig. 9, Sato, 1939, fig. 50 and Selenka & de Man, 1883, fig. 186b. They also differ from (1) *P. angulatus* (Ikeda, 1904) in the internal markings of the hooks (2) *P. speciosus* (Gerould, 1913) in the shape of the hooks and the number of longitudinal muscles (3) *P. schnehageni* (Fischer, 1913) in which the shields are not furrowed, the longitudinal muscles 10-14 and in which there is no fastening muscle (Ditadi, 1975) and (4) *P. tenuis* (Sluiter, 1886) in which the hooks are long and slender.

Edmonds (1956, pp. 308-9) identified two specimens from Low Is. as *Aspidosiphon klunzingeri*, remarking at the time that they lacked rectal appendages. I now think that I was wrong in so doing. I have re-examined them and consider that they should be placed in the synonymy of *P. johnstoni*.

Specimens examined and localities: Queensland —Low Is., (2) coll. Dr. P. E. Gibbs, SAM 1274; Two Is., (4) coll. Dr. P. E. Gibbs, SAM E1273; Raine Is. (11° 35' S, 144° 1' E) coll. I. M. Thomas, SAM E1272; Moreton Bay, in coral (8) coll. T. H. Johnston SAM E1270.



FIGS. 92-102. Figs. 92-93, *Paraspidosiphon formosanus;* 92, dissected specimen; 93, introvert hooks; spines and papillae. Figs. 94-96, *Aspidosiphon gracilis;* 94, dissected specimen; 95, introvert hooks; 96, spine from introvert. Figs. 97-99, *Aspidosiphon jukesii;* 97, introvert hook; 98, introvert spine (same scale as 97); 99, trunk papilla. Figs. 100-102, *Paraspidosiphon johnstoni;* 100, dissected specimen; 101, posterior shield; 102, introvert hooks.

Genus **Cloeosiphon** Grube

Cloeosiphon Grube, 1868b, p. 48; Selenka & de Man, 1883, p. 126; Stephen & Edmonds, 1972, p. 267.

Description: Trunk surmounted by a rounded to pineapple shaped cap, consisting of numerous, small, white, calcareous plates. Introvert arises from centre of cap. Rows of two-pointed hooks present on introvert. No cap or shield at posterior of trunk. Longitudinal muscles continuous. Spindle muscle fixed posteriorly. Two nephridia.

Type species: *C. aspergillus* (Quatrefages, 1865).

Remarks: Although four species have been described in this genus most workers consider them to be synonymous. *C. aspergillus* is commonly found in coral formations in most tropical seas.

Cloeosiphon aspergillus (Quatrefages)

(Figs. 15, 87-88)

Loxosiphon aspergillus Quatrefages, 1865, p. 605, pl. 20, fig. 20.

Cloeosiphon aspergillus: Selenka & de Man, 1883, pp. 126-7, pl. 2, figs 23-24, pl. 14, figs 214-216; Edmonds, 1956, pp. 309-310, fig 21, pl. 3, fig 2; Stephen & Edmonds, 1972, pp. 267-268.

Location of type: Not known by author: type locality: ??

Description: Trunk cylindrical, 10-45 mm long and 2·5-4·9 mm wide, bearing anteriorly a white, calcareous knob or cap, 2-5 mm in diameter and composed of small, white, polygonal plates of 4-6 sides, arranged in spiral rows. Each plate possesses a small brown pore. No cap, shield or knob at posterior extremity. Introvert slender, about as long as trunk, arises from centre of anterior cap and armed with double-pointed hooks. No spines on introvert.

Longitudinal musculature continuous. Trunk smooth although covered with glands, largest and most closely placed on anterior and posterior surfaces. Single retractor arising from two short roots. One fastening muscle. No intestinal caecum; spindle muscle fastened posteriorly. Nephridia dark, long (extending to base of retactor) and fixed for their entire length.

Systematic position: The identification of these specimens depends on the presence of the calcareous cap or knob and the shape of the introvert hooks. The cap is sometimes rounded, sometimes shaped like a pineapple or more flattened. The internal marking of the hook also varies to some extent. A number of authors consider that *C. japonicus* Ikeda, 1904, *C. javonicus* Sluiter, 1886 and *C. mollis* Selenka & de Man are synonymous. The matter is discussed in Stephen & Edmonds, 1972, p. 268.

Previous Australian records: Queensland: Munro, 1931; Edmonds, 1956.

Distribution: (1) in Australia: Queensland (in coral formations); Low Is., Heron Is., Lodestone Reef, One Tree Is.

(2) elsewhere: widely in the Indo-Pacific region.

Specimens examined and localities: Queensland—Heron, Is., SAM E1292 (8), E1293 (1), E1294 (2), Low Is., SAM E1301 (4); Townsville SAM E1295 (1).

Genus **Lithacrosiphon** Shipley

Lithacrosiphon Shipley, 1902, p. 139; Fischer, 1919b, p. 289, Fischer, 1922, pp. 26-28; Stephen and Edmonds, 1972, p. 259; Cutler and Jurczak, 1975, p. 243.

Description: Anterior end of trunk surmounted by a hard, calcareous, cone-shaped cap borne on a pad of skin; longitudinal muscles fit into pad. Introvert arises on ventral side of trunk or cap and bears numerous rows of hooks with one or two points. Longitudinal muscles form bands which may anastomose freely. Two retractors and two nephridia. Spindle muscle fixed posteriorly.

Type-species: *Lithacrosiphon maldivensis* Shipley, 1902.

Remarks: All the species so far described have been found in formations of coral. Cutler and Jurczak (1975) have critically reviewed the genus and reduced the number of species from 9 to 3. The valid species are now *L. maldivensis* Shipley (the type), *L. cristatus* (Sluiter) and *L. uniscutatus* (Ikeda). Only *L. cristatus* has been found in Australia.

Lithacrosiphon cristatus (Sluiter)

(Fig. 16)

Aspidosiphon cristatus Sluiter, 1902, p. 26, pl. 2, figs. 15-16.

Lithacrosiphon cristatus Fischer, 1922, p. 26; Cutler and Jurczak, 1975, p. 243.

Location of type: Zoological Museum, Amsterdam; specimen from Malaysia (Siboga Stn. 53, Waingapu).

Description: Specimens small; trunk of largest 9 mm long and 3 mm wide. Anterior region of trunk with form of a truncated cone, the surface of which is marked with a number of almost longitudinal furrows. Posterior to furrowed area trunk bears

prominent, hemispherical swellings or papillae. Introvert estimated to be about as long as trunk. Longitudinal muscles in 17-22 anastomosing bands. Two introvert retractors. Two nephridia about half as long as trunk. Both uni- and bidentate hooks present on introvert, those most distally being bidentate.

The identification of these specimens depends on the facts that (1) the anal shield is furrowed and (2) the distally placed hooks have two teeth while the proximal ones have one. No previous Australian record.

Distribution: (1) in Australia: Lizard Is., Queensland.

(2) elsewhere: "wide tropical distribution" (Cutler); Malaysia, Timor, Saipan, Gilbert Is., Hawaii, Panama and the Caribbean.

Specimens examined and localities: Queensland—Lizard Is. (8) coll. P. Weate AMS and (3) SAM E1289; Yonge Reef, east of Lizard Is., (1) AMS W10542.

Family Phascolosomatidae and key to genera

Phascolosomatidae Stephen and Edmonds, 1972 p. 269.

Description: Specimens bottle- or flask-shaped, sometimes sub-cylindrical. Finger-like tentacles lying in a near circle dorsal to mouth and surrounding nuchal organ. Longitudinal muscles grouped in bands, except in one small genus. Papillae conical to hemispherical in shape, often mamillate and darkly pigmented and usually covered with small platelets; most prominent and most densely grouped at anterior and posterior extremities of trunk. Retractor muscles four, very rarely two.

Type genus: *Phascolosoma* Leuckart, 1828.

KEY TO GENERA OF PHASCOLOSOMATIDAE

1. Species in which longitudinal musculature forms bands
Phascolosoma (p. 55)
Species in which longitudinal musculature is continuous
Fisherana†

Genus **Phascolosoma** Leuckart

Description: Trunk spindle-like sub-cylindrical, flash-shaped or fusiform. Longitudinal muscles always in bands, which may anastomose. Muscle bands not always visible externally but readily seen on dissection. Tentacles lie in a horse-shoe dorsal to mouth and enclose nuchal organ. Introvert and trunk usually covered with prominent, conical to hemispherical papillae, often brown to dark red-brown in colour. Trunk papillae usually largest and most densely distributed on anterior and posterior surfaces (especially on dorsal side). Retractors four, very rarely two. Contractile vessel single and usually simple.

Type species: *Phascolosoma granulatum* Leuckart, 1828.

SUBGENERA OF *PHASCOLOSOMA* AND KEY TO SUBGENERA

Stephen & Edmonds (1972, p. 271) divided the genus into four subgenera. Of these, two, *Phascolosoma* s.s. and *Satonus*, are known in Australia.

1. One pair of retractor muscles ..... *Rueppellisoma*
Two pairs of retractor muscles 2
2. Contractile vessel with villi or tubules ..... *Antillesoma*
Contractile vessel without villi or tubules 3
3. Spindle muscle fixed to posterior of trunk
Phascolosoma s.s (p. 56)
Spindle muscle not fixed to body wall posteriorly
Satonus (p. 61)

Remarks: Specimens of *Phascolosoma* are the most commonly collected intertidal sipunculans in Australia. They are found in limestone and coral reefs (some species bore into the rock; Rice, 1969, 1976), in masses of tubiculous polychaetes, in clumps of mussels, in rock crevices, under stones and in mangrove flats. Most appear to be detritus feeders (Rice, 1976). The larval development of some species has also been studied by Rice (1970). A list of the species reported from Australia is given on p.7 of the present paper.

Identification of species: I have not been able to construct a simple and satisfactory key tc the Australian phascolosomatids.

P. nigritorquatum, however, differs from all the other species because (1) its spindle muscle, according to the type description, is not fixed posteriorly (2) its mouth is surrounded by a row of very dark granular swellings and (3) the introvert bears four rows of hooks. It is not a well-known species.

The shape and markings of the introvert hooks and the structure of the papillae are two characters most commonly used in the identification of species. Consequently I have figured the hooks of all the species.

The hook of *P. noduliferum* has a comparatively wide base, a tendency to narrow near its mid length and a fine clear streak running from the apex to the mid-base. The papillae of *P. noduliferum* are usually hemispherical and carry few platelets; they are not

† Specimens of this small genus have not yet been found in Australia. Cutler & Murina (1977, p. 183) consider *Fisherana* better placed in the family Golfingiidae.

heavily pigmented and tend to be uniformly distributed. Pigmented bands on the introvert are lacking.

P. arcuatum differs from other species in (1) the arrangement of its retractor muscles (2) the presence of sub-epidermal coelomic extensions (3) the tendency of its circular musculature to form small bundles and (4) its lack of fixing muscles. The clear area of the hook is very wide basally. The species has been found only in association with mangroves.

The papillae of *P. annulatum* are covered with large contiguous, polygonal plates which usually are darker in colour at the base of the papillae. Polygonal plates like those on the papillae are scattered on the body wall between the papillae. The hook of *P. annulatum* is "*scolops-agassizi*"-like and consequently not a very useful distinguishing character.

The hook of *P. albolineatum* is stout; its pointed part is strongly bent and lies almost parallel to the base of the hook. The central clear "streak" is wide and slopes sharply to a basal corner of the hook. There is a well developed clear, triangular area on the side of the streak away from the tip of the hook.

The papillae of *P. pacificum* tend to be sharply conical so that specimens may feel "bristle-like". The introvert hook is sharply bent, its clear streak widens basally and it possesses a clear triangular area. The nephridia extend almost to the extremity of the trunk and are fixed to the body wall for most of their length. Specimens are sometimes mottled in colour.

The hook of *P. stephensoni* has a clear triangular area on one side of the clear streak that runs from the apex to the base and on the other side a clear crescentic area. The latter is characteristic.

The hooks of *P. rottnesti* and *P. scolops* resemble each other closely except that the clear streak of *P. rottnesti* may sometimes be slightly swollen near its middle. A rectal caecum, reported to be absent in *P. scolops*, is present in *P. rottnesti*. The papillae of *P. rottnesti* consist of more numerous and smaller platelets than those of *P. scolops*.

In *P. perlucens* a number of claw-like papillae or spines are present at the base of the introvert (especially on the dorsal side) and on the posterior region of the trunk. The hook is bent rather sharply.

The clear streak of the hook of *P. nigrescens* is swollen slightly in its upper half and very much expanded posteriorly. The basal part of the expansion is indented slightly so as to form a bulge or a tongue which is directed towards the tip of the hook.

I now consider that *P. heronis* Edmonds, 1956 and *P. dunwichi* Edmonds, 1956 were incorrectly named; the former should have been called *P. stephensoni* (Stephen, 1942) and the latter *P. scolops* (Selenka and de Man, 1883). The reasons for the changes are given in the text.

Phascolosoma (Phascolosoma) albolineatum Baird

(Fig. 106)

Phascolosoma albolineatum Baird, 1868, pp. 91-92; Rice and Stephen, 1970, p. 59; Stephen and Edmonds, 1970, p. 293.

Phymosoma albolineatum Selenka and de Man, 1883, pp. 71-74, pl. 9, figs. 128-129.

Location of type: Nat. Hist. Museum, London, reg. no. 1925.25.1; specimen from Philippine Is.

Description: This description is based on the four specimens mentioned below and 16 others from the Solomon Is. Trunk off-white to pale straw in colour except at junction with introvert where it is dark brown; length 9-34 mm and width (in mid-region of trunk) 3-8 mm. Straw coloured introvert, about half to three quarters as long as trunk, with a number of black bands of varying size on its dorsal side. An almost complete ring of short, stubby, light tentacles (26 in one specimen) lies dorsal to mouth. Immediately posterior to mouth there is a smooth collar-like region. Posterior to collar, introvert is armed with rows (28 in one specimen) of dark coloured stout hooks, with a strongly bent tip. Central, clear region of hook wide and slopes sharply to basal corner. A triangular shaped, clear area lies basally on one side of central clear area.

Papillae on introvert brown, pointed, sub-conical or mamillate, becoming larger and more densely placed basally. Papillae on trunk largest anteriorly and 0·2-0·3 mm in diameter; in mid-trunk region they are smaller and more scattered and about 0·15 mm in diameter and posteriorly slightly larger and closer together.

Longitudinal musculature in about 20 anastomosing bundles. Four retractors, arising in posterior half of trunk; a stout ventral pair from muscles 2-6 or 2-7 and a more slender, dorsal pair more anteriorly from bands 4-6 or 5-7. Oesophagus fastened to retractors by thin mesenteries. A strong fastener arising from muscle 1 on left side near base of dorsal retractor runs towards junction of oesophagus and intestinal spiral, giving off one branch to posterior oesophagus and another branch to last spiral of intestine. No rectal caecum. Wing muscle strong. Spindle muscle attached near anus and at posterior extremity of trunk. Contractile vessel simple. Nephridia, about half as long as trunk, fixed for about half their length and attached at same level as anus.

Remarks: The shape of the hooks is a very useful specific character of this species.

No previous Australian record.

Distribution: (1) in Australia: Great Barrier Reef, Queensland.

(2) elsewhere: an Indo-Pacific species: Natal, Aboina, Java, Indo-China, Philippines, Japan, Tokara Is., Palau, West Caroline Is.

Specimens examined and localities: Queensland —Great Barrier Reef at Three Is., (2) SAM E1315 and at Casuarina Beach, Lizard Is., (2) WAM 220/76.

Phascolosoma (Phascolosoma) annulatum Hutton

(Figs. 103, 107-8)

Phascolosoma annulatum: Hutton, 1879, p. 278; Benham, 1903, p. 174; Edmonds, 1960, pp. 160-2, text figs. 1-2; Stephen and Edmonds, 1972, pp. 296-297; Cutler, 1977, p. 151.

Physcosoma scolops var. *mossambicense* Augener, 1903, p. 339 (in part).

Physcosoma scolops var. *tasmaniense* Fischer, 1914, p. 3, pl. 1, figs. 4-6.

Physcosoma scolops Wheeler, 1938, p. 346.

Phascolosoma tasmaniense Edmonds, 1956, pp. 285-286, figs. 5-6.

Location of type: Not known by author; specimen from Campbell Is., New Zealand.

Description: Trunk 25-49 mm long and 4-7 mm maximum width. Introvert about as long as trunk (in fixed specimens), with 20-30 short finger-like tentacles lying in a near ring dorsal to mouth. Numerous rows of dark coloured introvert hooks, resembling those of *P. scolops* (Selenka and de Man) and *P. agassizii* Keferstein. The hook possesses (1) a clear streak (sometimes swollen near its middle) running down through the "centre" of the hook and (2) a clear triangular area on one side of the streak.

Specimens brown but anterior and posterior of trunk made dark- to red-brown or almost black by pigmentation of papillae. Papillae at base of introvert dark red, conical and closely packed, particularly on dorsal surface; those on anterior and posterior surface of trunk largest, most prominent, conical or hemispherical, about 0·2-0·4 mm in diameter and densely packed. Papillae may coalesce or run into one another; composed of polygonal plates set closely together. At base of papillae there is usually an almost complete ring of what appears to be darker plates, much as is shown for *Phascolosoma japonicum* (Grübe;) by Sato (1939, fig 29). Papillae on mid-region of trunk smaller and more scattered. A feature of the species is that dark-brown polygonal plates are scattered over the surface between papillae. Whether they are detached plates of the larger papillae is not certain. A number of pigmented bands, usually best developed on dorsal side, partly surround anterior surface of introvert. Pigmented patches sometimes appear on trunk.

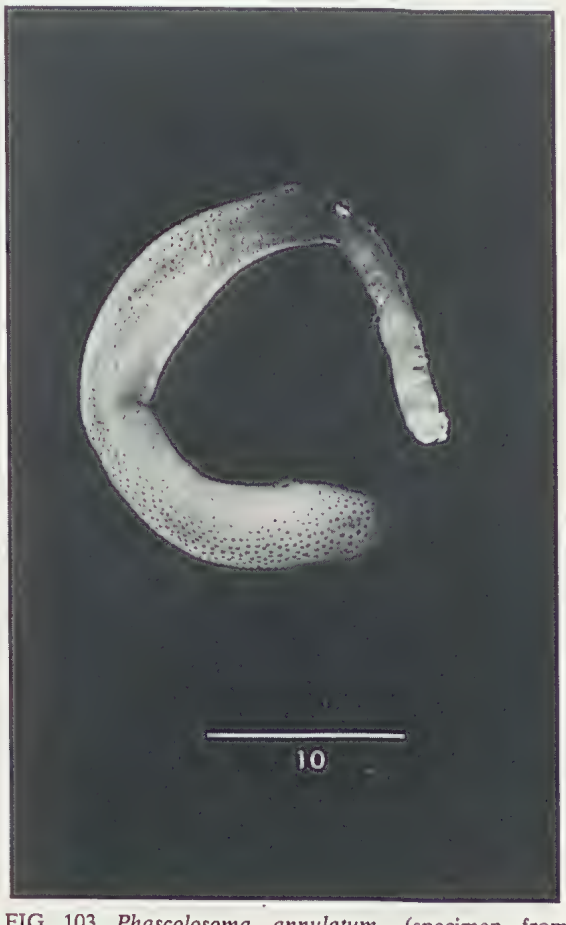


FIG. 103. *Phascolosoma annulatum*, (specimen from South Australia).

Longitudinal muscles in 18-25 anastomosing bands, usually visible externally. Two stout ventral retractors arising from muscles 2-5, 2-6, 2-7; 3-5 or 3-6 and two more slender dorsal retractors from 5-6, 4-6 or 4-7 are attached to posterior half of trunk. One fastening muscle, connecting muscle 1 on left side to last spiral of intestine, may bifurcate giving a second root to oesophagus. Contractile vessel without villi. Spindle muscle arises anteriorly near anus and is fixed posteriorly. Nephridia, usually about half length of trunk fixed to body wall for about half to two thirds of their length and arising near anus. Gonads at base of ventral retractors. Largest sub-elliptical eggs 0·11-0·13 mm long. Rectal caecum present in some specimens from South Australia (SAM 1323), rudimentary or absent in others but present in those from New Zealand (SAM 1324 and 1325).

Sytematic position: *P. annulatum* differs from all other Australian phascolosomatids in the structure

of its papillae and in the presence of platelets on the body wall between the papillae. The platelets are polygonal and appear to be detached platelets from the papillae. It differs from *P. agassizii* Keferstein in the structure of the papillae and from *P. japonicum* Grübe which lacks polygonal platelets on its surface.

In spite of the fact that the rectal caecum is better developed in New Zealand specimens I regard the specimens from southern Australia and New Zealand as the same species. According to Cutler (1977, p. 151), Wesenberg-Lund in an unpublished work disagreed with this. Although I have not examined Augener's, Fischer's nor Wheeler's specimens I have placed them in the synonymy of *P. annulatum*. Figs. 4 and 5 of Fischer (1914) are the papillae and platelets of *P. annulatum* and the Sir Joseph Banks Group of islands, where Wheeler's material was collected, lie off Port Lincoln, South Australia, a locality where *P. annulatum* is commonly collected.

Previous Australian records: Augener (1903), Fischer (1914), Wheeler (1938) and Edmonds (1956).

Distribution: (1) in Australia: along coast of South Australia from Baird Bay (Eyre Peninsula) to Kilcunda; Victoria; along northern and eastern coasts of Tasmania.

(2) elsewhere: New Zealand; Campbell and Stewart Islands.

Specimens examined and localities: South Australia—Nuyt's Archipelago (2) SAM E1529; Baird Bay (5) SAM E1231; Pearson Is. (12) SAM E1528; Grindel Is. (5) SAM E1334; Port Lincoln "in calcareous reef" SAM E1322; Cape Donnington (2) SAM E1333; West Is. (1) SAM E1329; Corny Pt. (8) SAM E1329; Pondalowie Bay (5) SAM E1396; Beachport (3) SAM E1527; Emu Bay, Kangaroo Is., (2) SAM E1537; Stokes Bay, Kangaroo Is., (4) SAM E1532; Elliston (10) SAM E1540. Victoria—Shoreham (5) SAM E1327 and (1) NMV G1218; Portland (1) coll. NMV; Cape Patterson (1) coll. NMV; Kilcunda (5) coll. NMV. Tasmania—Eaglehawk Neck (3) SAM E1331 and (1) TMH K101-1553; Port Latta (1) coll. NMV; Dunally (5) TMH K166; Fossil Is. (1) TMH K82-14482; Taroona Beach (1) TMH K206; Bicheno (2) coll. NMV; Erith Is. (1) AMS W6562.

Phascolosoma (Phascolosoma) arcuatum (Gray, 1828)

(Figs. 104, 109-111)

Sipunculus arcuatus Gray, 1828, p. 8.

Phascolosoma arcuatum: Baird, 1868, p. 88; Rice and Stephen, 1970, pp. 50-52, pl. 1.

Phymosoma lurco Selenka and de Man, 1883, pp. 61-63, pl. 1, fig 5, pl. 8, figs 103-110.

Physcosoma lurco: Fischer, 1895, p. 12.

Phascolosoma lurco: Edmonds, 1956, pp. 290-291, text fig 10.

Location of type: Nat. Hist. Museum London; specimen from India.

Description: Trunk stout, almost uniformly cylindrical, 15-120 mm long and 6-10 mm wide; body wall light-brown to brown except at anterior and posterior of trunk where it is usually dark-brown to brown-black. Posterior extremity of trunk may be invaginated slightly.

Introvert of fixed specimens with length varying from half to same as that of trunk. Horseshoe-shaped ring of tentacles lies dorsal to mouth. More posteriorly as many as 75 complete or partially complete rows of dark coloured hooks, with a large expansion basally of clear streak which runs from apex to base. Papillae between rows of hooks small, about 0·02 mm in diameter, those at extremities of trunk larger, 0·5-0·6 mm in diameter, prominent and very dark, consisting of numerous polygonal plates. Their structure is clearly shown in pl. 1, fig. 2 of Rice and Stephen (1970).

Longitudinal muscles in 16-23 broad, anastomosing bands not always visible externally. Circular muscles tend to form fascicles, as shown in fig. 103 of Selenka and de Man (1883). Rice and Stephen (1970, p. 50) point out that small coelomic pockets extend into spaces between longitudinal and circular musculature. Four retractors fixed to body wall in posterior third of trunk, a strong ventral pair to muscles 1-2, 2-3, or 1-3 and a more slender dorsal pair more anteriorly to 1-2 or 2-3. Retractors fuse for most of their length into one, larger flat muscle. Thin walled oesophagus attached to fused part of retractor for most of length of latter. Spindle muscle fastened anteriorly near anus and posteriorly to body-wall. Rectum short and without a caecum. No fastening muscle. Wing muscle strong. Nephridia about half to three quarters as long as trunk and fixed for about three quarters of their length. Contractile vessel without villi. Gonads at base of ventral retractors. Brain, a white swelling with pigmented eyespots.

Systematic position and remarks: This species is distinguished from other Australian phascolosomatids by (1) the structure of the introvert hooks (2) the arrangement of the retractors and (3) the presence of subepidermal, coelomic extensions. It is associated with mangroves and was for a long time known as *P. lurco*. Harms and Dragendorf (1933) and Green and Dunn (1976) have studied the ionic and osmotic balance of the species.

FIG. 104. *Phascolosoma arcuatum*, (specimen from Rockhampton, Queensland).

P. arcuatum, according to Green and Dunn, lives from the highest to the lowest levels of mangrove swamps along the west coast of peninsular Malaysia and consequently is subject to extremely variable salinities. According to their researches *P. arcuatum* is physiologically an osmoconformer. Green (1975) has studied the reproductive cycle of Australian specimens.

Previous Australian records: Baird (1868), Fischer (1895), Edmonds (1956).

Distribution: (1) in Australia: in mangrove flats in Queensland at Sandgate, Townsville and Rockhampton and in Western Australia at Derby.

(2) elsewhere: Malaysia, Indo-China, Philippines and Java.

Specimens examined and localities: Queensland —mouth of Ross River "in mangroves" (8) SAM E1335; Sandgate (5) SAM E1336 and (3) AMS W3605; Calliope River (3) "amongst mangrove seedlings" SAM E1526; Townsville "in mangroves" (10) SAM 1337. Western Australia—Derby (King Sound) "in mangroves on tidal flat" (2) SAM E1388 and E1389.

Phascolosoma (Phascolosoma) nigrescens Keferstein

(Fig. 112)

Phascolosoma nigrescens Keferstein, 1865, p. 424, pl. 32, fig. 14-15; Edmonds, 1956, p. 289, text fig. 9; Stephen and Edmonds, 1972, p. 315.

Phymosoma nigresecens Selenka and de Man, 1883, pp. 73-74, pl. 9, figs. 130-137.

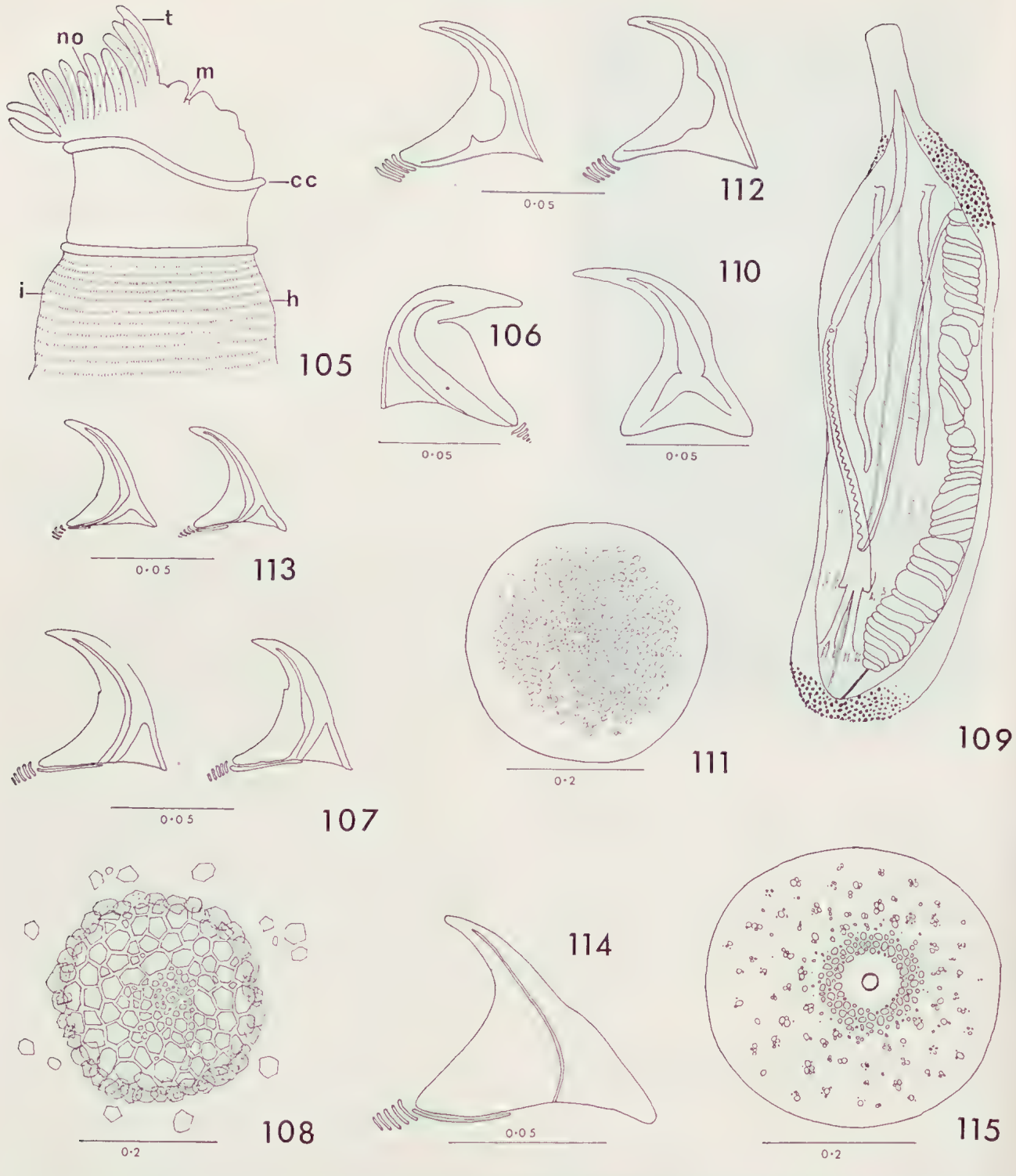
Location of type: Not known to author; specimen from Fiji.

Description: Trunk 15-45 mm long and 2·5-6 mm wide, light to dark-brown in colour. Introvert of fixed specimens may be as long as trunk but usually shorter, with group of short tentacles dorsal to mouth. Smooth collar present on introvert and more posteriorly 18-35 rings of light to dark-brown hooks (fig. 112). Although the clear area that runs from the apex of the hook towards its base is always expanded slightly in the middle, the shape of the clear area basally varies noticeably; in specimens from Broome there is a small hump but in those from Low Is. and Myora the hump is enlarged to a tongue-like protrusion. Introvert with stoutly conical papillae (0·05-0·07 mm in diameter) between rows of hooks, and usually with a number of pigmented bands on dorsal surface.

Papillae on trunk and introvert numerous, pointed and more uniform in shape and distribution than in most *Phascolosoma*. At posterior extremity of trunk papillae concial to mamillate, about 0·2 mm tall and 0·2 mm broad, with a pore at apex and consisting of dark coloured, elongate, radiating plates. A number of very dark papillae may be scattered randomly on trunk and introvert of specimens.

Longitudinal muscles in about 20 anastomosing bundles. Two stout ventral retractors arise in mid-third of trunk from muscles 1-7, 2-7, 2-8, or 3-9 and two slenderer dorsal retractors more anteriorly from 6-8, 5-8 or 7-9, the dorsal and ventral muscle on same side of nerve cord soon fusing. Strong spindle muscle attached near anus and at posterior extremity of trunk. Rectum and spindle muscle may fuse for part of length. A fastening muscle to posterior intestine may give a branch to oesophagus. Strong wing muscle and rectal caecum present. Contractile vessel simple. Nephridia fixed for half or third of their length, about half as long as trunk and arising at about level of anus.

Systematic position: This species is identified largely by the structure of its hooks as shown in figs. 130 and 135 of Selenka (1883) and in the present material. Edmonds (1956) mentioned that the contractile vessel of his specimens possessed very



FIGS. 105-115. Fig. 105, anterior region of introvert of a *Phascolosoma*, showing position of tentacles, mouth and nuchal organ (after Theel). Fig. 106, *Phascolosoma albolineatum*; introvert hook. Figs. 107-108, *Phascolosoma annulatum*; 107, introvert hooks; 108, trunk papilla. Figs. 109-111, *Phascolosoma arcuatum*; 109, dissected specimen; 110, introvert hook; 111, trunk papilla. Fig. 112, *Phascolosoma nigrescens*; introvert hooks. Fig. 113, *Phascolosoma nigritorquatum*; introvert hooks (from one of Sluiter's specimens). Figs. 114-115, *Phascolosoma noduliferum*; 114, introvert hook; 115, trunk papilla.

small villi. Although I have not been able to re-examine the same specimens I now think that I mistook some very small wrinkles or crenations of the muscular wall of the vessel to be villi.

It is difficult to find a satisfactory character which can be used to distinguish *P. nigrescens* from *P. puntarenae* Grübe. The relationship between the two is discussed by Fisher (1952, p. 430-432). If they are the same, *P. puntarenae* Grübe, 1859 has priority. The species is often associated with coral formations.

Previous Australian records: Queensland—Low Is.; (Munro, 1931); Heron Is. (Edmonds, 1956). Western Australia—Cape Jaubert (Fischer, 1921); Shark Bay (Fischer, 1919a), Cape Dennison (Edmonds, 1956).

Distribution: (1) in Australia—Queensland; northern New South Wales; north west Australia.

(2) elsewhere: widely in Indo-Pacific region; West Africa.

Specimens examined and localities: Queensland —Low Is., "in coral" (2) SAM E1344; Magnetic Is., (1) SAM E1345; One Tree Is., (1) SAM E1346; Three Is., (1) SAM E1347; Cockle Bay (2) SAM E1350; Myora (1) SAM E1351; Wistari Reef (Capricorn Group) (2) SAM E1352. New South Wales—Woolgoga (1) coll. NMV; Lennox Head (3) AMS W10545 and (6) AMS W10544. Western Australia—Cable Beach (near Broome) (3) SAM E1349; Broome (Pt. Gantheaume) (3) WAM 10922; Dampier Archipelago (1) WAM 132/76 and (1) WAM 222/76.

***Phascolosoma (Satonus) nigritorquatum** (Sluiter)

(Fig. 113)

Phymosoma nigritorquatum Sluiter, 1882, pp. 151-152, pl. i, figs 3, 8, 11; Selenka and de Man, 1883, pp. 68-69.

Physcosoma nigritorquatum: Sluiter, 1902, p. 13; Fischer, 1919a, p. 280; 1921, p. 4-5, figs 1-2; 1927, p. 416.

Phascolosoma nigritorquatum: Stephen & Edmonds, 1972, p. 186.

Location of type: Zoological Museum, Amsterdam; specimen from Batavia "from coral islands".

Description: I have not examined any Australian specimens of the species. It has, however, been reported twice from Western Australia by Fischer (1919a, 1921). According to Sluiter the length of the body is 2·5-3 times its width. Posterior region pointed. Papillae very numerous, especially at anterior and posterior extremities of trunk. Longitudinal muscles in 20-22 bands and circular musculature continuous. Introvert about a quarter as long as body. Two anterior retractors weaker than two placed more posteriorly. A narrow papillae-free zone at base of introvert. A row of black granulated bodies? ("Körner") and swellings? ("Wülste") lie in a half ring around margin of mouth. The pigmented bands extend in successive rows around anterior part of introvert. Four rows of small, slender introvert hooks. Tentacles arising from two folds. Intestine with only a few, nine, spirals. No spindle muscle. Two anteriorly swollen nephridia. Colour of animals dark yellow to brown. Length without introvert 13 mm.

In a "discussion" that follows the description, Sluiter says that the black bands? or ridges? ("Leiste") on the introvert are characteristic of the species and that sometimes they anastomose. The first of the black bands is never completely invaginated and remains visible even if the introvert is retracted.

The account of Selenka & de Man is only a repetition of Sluiter's. Fischer (1921, p. 5) records that a specimen from Western Australia is 12 mm long and its introvert 8-9 mm. Skin yellow-white. Introvert hooks sickle-shaped and in 5-6 rows. Longitudinal muscles in 20-22 bundles. Two broad ventral retractors arise in posterior third from muscles 2-7. Intestine of 10-12 double spirals. Fischer says that a spindle muscle is present and that it is fixed posteriorly.

Systematic position: Recently I have re-examined two of Sluiter's specimens (V 51, 80, Baai v. Batavia) from the Zoological Museum, Amsterdam. The tube containing them bears the label "type"; one was partly dissected. Body small, trunk 5-8 mm long and 2·5-4 mm maximum width; pointed posteriorly. Introvert of each specimen almost completely retracted. Longitudinal muscles in 19-23 bundles visible externally; some anastomosation. Papillae most prominent on anterior and posterior surfaces of trunk; often sharply pointed and spine-like. Surface of papillae carries small rounded-polygonal platelets (much like those of *P. scolops)* and underlying there seem to be rather long radially arranged plates. In the specimen that I dissected a number of red-brown bands were found on the introvert, especially the dorsal surface. I was not able to find Sluiter's "intens schwarzer Körner and Wülste". A few rows of clear, unpigmented introvert hooks were present (fig. 113); they do not correspond very well with those drawn by Sluiter and Fischer and resemble closely those of *P. scolops* and *P. rottnestii*. Introvert retractors four, the dorsal and ventral pair on each side almost spanning the same number of muscles. The gut of the specimen which I dissected was thin, frail and not in good condition and that of the other (I extended the cut already present a little further anteriorly and posteriorly) was surrounded by coagulated material which was difficult to remove. In neither was I able to find a spindle muscle anteriorly nor the point of attachment of such a muscle near the anus. No sign of a posteriorly placed spindle muscle was present in one specimen but in the other a stout muscle emerges from the last intestinal spiral and is attached to the body wall. Consequently I have not been able to check conclusively whether a spindle muscle is present or absent in *P. nigritorquatum*. The answer is important because in the subgenus *Satonus* a spindle muscle is either absent or not attached posteriorly. *P. nigritorquatum* is the type of the subgenus. If *P. nigritorquatum* possesses a spindle muscle *Satonus* is invalid and another subgenus must be erected and a new type found. No information about the presence of a caecum or fastening muscle can be given. The two nephridia are free. Some sub-elliptical-shaped eggs (0·10-0·13 mm) long and (0·07-0·075 mm) wide

with a nucleus about 0·025 mm in diameter were present.

Previous Australian records: Fischer, 1919a; 1921.

Distribution: (1) in Australia—Western Australia, Cape Jaubert and Shark Bay.

(2) elsewhere: Bay of Bantam, Indonesia.

Phascolosoma (Phascolosoma) noduliferum Stimpson

(Figs 114-115)

Phascolosoma noduliferum Stimpson, 1855, p. 390; Keferstein, 1865, p. 423, p. 32, figs 16-17; Edmonds, 1956, pp. 286-288, text figs 7-8; Cutler, 1977, p. 152.

Physcosoma grayi Baird, 1868, pp. 88; Rice & Stephen, 1970, p. 52.

Location of type: Not known to author; specimen from Port Jackson, New South Wales.

Description: Trunk 12-65 mm long and 3-7 mm wide, brown or light brown in colour with only a slight darkening at its extemities. Introvert of fixed specimens about as long as trunk, lacking pigmented bands but possessing (1) about 20-25 short, digitiform tentacles and (2) a varying number of dark brown hooks (fig. 114). Shape of hook distinctive, with broad base and a thin clear streak, running from apex to base of hook.

Papillae usually hemispherical and more uniformly distributed on trunk than in *P. annulatum;* largest 0·3-0·4 mm in diameter, consisting of numerous small plates and scattered granules. Longitudinal musculature in 20-26 bands, not always visible externally because body wall is thick. Four retractors, a stout ventral pair attached to muscles 2-6, 2-7 or 1-6 in posterior half of trunk and a weaker dorsal pair more anteriorly to muscles 4-6, 5-7 or 6-7. Oesophagus fixed to retractors by two short mesenteries. Spindle muscle fixed anteriorly near anus and posteriorly to body wall. Wing muscle well-developed. A fastening muscle arising from muscle 1 or 2 near base of left ventral retractor runs to last or penultimate intestinal spiral; sometimes supplying a branch to oesophagus.

Nephridia half to three quarters as long as trunk and fixed for about three quarters of their length. Contractile vessel simple. No rectal caecum. Brain appears as slight swelling in some specimens; two eyespots. Elliptical eggs about 0·12 mm in diamter.

Systematic position: Edmonds (1956, p. 288) discussed at some length the status of this sipunculan commonly collected along the eastern and southern coasts of Australia and which has often been called *P. japonicum* (Selenka and de Man, 1883, p. 77; Dakin, 1952, p. 157 and Whitlegge, 1899, p. 11). This probably stems from the identification of two specimens from New South Wales as *P. japonicum* by Selenka and de Man, 1883. The two specimens, registered as 85.12.3.30 and 85.11.3.30, are in the British Museum (Natural History, London). They possess the hooks and papillae of *P. noduliferum* and not *P. japonicum.*

There is considerable overlap in the distribution of *P. noduliferum* and *P. annulatum* in Victoria and Tasmania. Specimens of both have been recorded from Eaglehawk Neck, Dunally and Bicheno (in Tasmania) and from Kilcunda and the Nobbies (in Victoria). The differences in their habitats at these places is not known. *P. noduliferum* occurs in New South Wales, Victoria, Tasmania and South Australia. Two specimens are also known from the South coast of Western Australia.

P. noduliferum differs from allied Australian species in the structure of its hooks and papillae. Pigmented bands on the introvert have not been described for the species.

Previous Australian records: Stimpson (1885); Edmonds (1956); Cutler (1977) (7 specimens dredged at 85-1340 m off South Australian coast).

Distribution: (1) in Australia—New South Wales, Victoria, Tasmania, South Australia and south coast of Western Australia.

(2) elsewhere—Malacca Sts. (at 1140 m), Mindanao (at 22 m), Pt. Moresby (New Guinea) (at 8 m), Campbell Is. (off south coast of New Zealand). All of these records are from Cutler (1977, p. 152).

Specimens examined and localities: New South Wales—Newport (6) SAM E1353; Long Reef (3) SAM E1354 and (1) AMS W10548; near Sydney (6) SAM E1356; Harbord (3) AMS coll.; Botany Bay (2) AMS W548. Victoria—the Nobbies, Western Port (8) SAM E1355 and (1) NMV G1129; Phillip Is. (2) SAM E1357; Godfrey reef near Lorne (1) NMV coll.; Cape Bridgewater (1) NMV coll.; Portsea Pier (1) NMV coll.; Malacoota (2) AMS W10547. Tasmania—Bicheno (2) NMV coll.; Jacobs Boat Harbor (1) TMH coll.; Dunally (2) TMH K/166; Eaglehawk Neck (8) TMH coll.; and (2) TMH K102/15532 and (5) SAM E1397; Erith Is. (1) AMS W10569. South Australia—Cape Northumberland (1) SAM E1390. Western Australia—10 miles east of Hopetown (1) SAM E1400; off south coast (35° 15′ S, 126° 22′ E) (1) WAM 145/76.

Phascolosoma (Phascolosoma) pacificum Keferstein

(Figs. 120-121)

Phascolosoma pacificum Keferstein, 1866, pp. 8-9; 1867, pp. 49-50, pl. 6, Figs 1-2, Edmonds, 1956, pp. 291-292, text fig. 11, Stephen and Edmonds, 1972, pp. 317-318.

Phymosoma pacificum: Selenka and de Man, 1883, pp. 63-65, pl. 2, fig 6, pl. 7, figs 111-112.

Location of type: Not known to author; specimen from Gilbert and Tarawa Is. (Kingsmill Group, Pacific Ocean).

Description: Trunk of largest specimen 102 mm long and maximum width (in posterior third of trunk) about 8 mm. Light brown to brown in colour with a darker mottling in some specimens. Mottling on anterior surface of trunk may be less irregular and more band-like, especially on dorsal surface. Body wall thick and banding of longitudinal muscles not usually visible externally.

Introvert in fixed specimens about as long as trunk, with a group of digitiform tentacles dorsal to mouth and with numerous complete and incomplete rows of large, dark-brown hooks, 0·07-0·10 mm wide basally and 0·07-0·09 mm tall.

Papillae on introvert and trunk numerous, closely packed, sharpely pointed and conical so that animal feels rough and bristle-like (a fact mentioned by Selenka and de Man). On mid-region of introvert papillae 0·20-0·25 mm tall, 0·15-0·2 mm wide; on posterior of trunk becoming 0·3 mm tall, 0·3 mm wide. Papillae composed of very small granules with a pore at apex.

Longitudinal muscles in anastomosing bundles, about 20 anteriorly and 35-40 posteriorly. Four retractors, a stout ventral pair arising in mid-third of trunk and attached to muscles 2-7 or 2-8, and a dorsal pair more anteriorly and attached to same six or seven muscles. Retractors fuse anteriorly. Intestinal contents of coarse sand and coral fragments. One fastener to last or second to last spiral or intestine. Spindle muscle stout and attached posteriorly. No caecum in two dissected specimens. Contractile vessel simple. Nephridia pigmented brown or brown-black, very long (extending almost to extremity of trunk) and fixed to trunk wall for their whole length.

Systematic position: This species is identified by the size and shape of its introvert hooks and the presence of nephridia which extend almost to the posterior extremity of the trunk and which are fixed to the body wall for their whole length.

Previous Australian records: Queensland—Low Is. (Monro, 1931); Heron Is. (Edmonds, 1956).

Distribution: (1) in Australia—Great Barrier Reef, Queensland; Northern Territory.

(2) elsewhere: Indo-Pacific, Madagascar, Zanzibar, Mauritius, Red Sea, Amboina, Indo-China, Japan, Philippines, Gaum, New Britain, West Carolines.

Specimens examined and localities: Queensland—Heron Is. (1) SAM E1358; Low Is. (1) SAM E1359; Turtle Is. (2) SAM E1360; Dunwich (1) SAM E1364; Michaelmas Reef, Cairns (2) AMS coll. Northern Territory—Fannie Bay Rocks, Darwin (1) AMS coll.

Phascolosoma (Phascolosoma) perlucens Baird

(Figs. 117-119)

Phascolosoma perlucens Baird, 1868, p. 90, pl. 10, fig. 2; Rice and Stephen, 1970, pp. 63-64.

Phymosoma dentigerum Selenka and de Man, 1883, pp. 67-68, pl. 1, fig. 7, pl. 9, figs. 118-123.

Phascolosoma dentigerum: Fisher, 1952, pp. 432-434, pl. 36, figs. 4-7.

Location of type: Nat. Hist. Museum, London. reg. no. 1847.12.30.11; specimen from Jamaica (in coral rock).

Description: Specimens tend to be slender and straw coloured in alcohol. Trunk of largest 45 mm long and 4-5 mm wide. Body wall thin and almost transparent in some regions. Introvert about half to three quarters as long as trunk (in fixed specimens) with (1) a number of very dark-brown bands on dorsal surface (2) prominent, dark-red-brown, spine-like papillae or tubercles on posterior dorsal surface and (3) rows of light- to dark-brown hooks anteriorly. Spine- or claw-like papillae mostly point backwards and vary in size, the largest being about 0·6-0·7 mm tall and about 0·5 mm wide basally (fig. 00). A fine tube runs from tip of spine to its base, the diameter of tube increasing basally. Anterior half or third of hook strongly bent and lying almost parallel to base of hook; central clear area expanded near its middle and a clear triangular area present basally. Papillae on posterior trunk darker than on trunk and tend to be claw-like; largest about 0·3 mm tall and 0·25 mm wide at base. Posteriorly placed claw-like papillae of two Australian specimens not as prominent as those shown in Fisher, 1952, pl. 39, fig. 5.

Longitudinal muscles in about 22 anastomosing bands. Retractor muscles four, a ventral pair attached to muscles 2-7 or 2-6 in mid-third of trunk and a dorsal pair more anteriorly to 5-8. Contractile vessel slender and without villi. One fastening muscle to last spiral of intestine. Caecum not observed (Fisher, 1952 claims that one is present). Nephridia fixed to trunk for about one third of their length and about one third as long as trunk.

Systematic position and remarks: The shape of the introvert hooks and the presence of large claw-like structures on the dorsal surface of the introvert make this one of the easier species of *Phascolosoma*

to identify. Fisher (1952) redescribed and figured it. The species is probably better known in the literature as *P. dentigerum*. The Australian specimens were collected in coral rock. Rice (1976) describes the feeding behaviour of the species.

Previous Australian record: Low Is., Queensland (Monro, 1931).

Distribution: (1) in Australia—Great Barrier Reef, Queensland.

(2) elsewhere—Baja California, Gulf of Panama, Rotuma, Funfuti, Marshall Is., Eniwetok Atol, Philippines, Laccadive Is., Batavia, Madagascar, and the West Indies.

Specimens examined and localities: Queensland—on Great Barrier Reef; Three Is., (1) SAM E1365; Tree Is.; (2) SAM E1366; One Tree Is., (1) AMS W5525; Lizard Is., "in coral" (3) SAM E1395.

Phascolosoma (Phascolosoma) rottnesti Edmonds

(Figs. 116, 124-126)

Phascolosoma rottnesti Edmonds, 1956, pp. 282-284, text figs. 1-4.

Physcosoma agassizii Fischer, 1919a, p. 277; Fischer, 1922, p. 7, pl. 1, figs. 3, 5 and 6.

Location of type: Australian Museum, Sydney; specimen from Rottnest Is., Western Australia, "from burrows in calcareous rock".

Description: Trunk 10-52 mm long and maximum width (in posterior third) 3-5 mm. Expanded introvert of fixed specimens about as long as trunk. Freshly collected animals pale to pink-brown in colour except at extremities of trunk which are dark- to red-brown. Red-brown bands, varying in number and width, usually present on dorsal surface of introvert. Trunk of few specimens is mottled by a number of red-brown spots. Partial ring of tentacles lies dorsal to mouth. From 15-45 rows of light to dark brown hooks, resembling those of *Phascolosoma scolops* (Selenka and de Man 1883, fig. 143) and *Phascolosoma agassizii* Keferstein, 1867, pl. 6, fig. 4 but not fig. 8, present on introvert anteriorly. A clear triangular area is always present on one side of the clear streak, which runs from the apex of hook to its base.

Papillae between rows of hooks very small and forming complete transverse rings; towards base of introvert they are larger, about 0·1 mm in diameter, pointed or conical and darker in colour. On anterior surface of trunk papillae larger, especially on dorsal side, 0·2-0·35 mm in diameter, more hemispherical, more densely packed and dark brown in colour. In mid-trunk region papillae smaller, rounded, more scattered and less prominent. On posterior surface

FIG. 116. *Phascolosoma rottnesti*, (specimen from Rottnest Island, Western Australia).

they are large, 0·2-0·45 mm in diameter, closely packed and dark brown. All papillae consist of small plates of almost uniform size.

Longitudinal muscles in 20-24 anastomosing bands, not always visible externally. Four retractor muscles, a strong ventral pair arising in posterior half of trunk from muscles 2-5, 2-6, 2-7 or 3-7 and a weaker dorsal pair more anteriorly from 4-6, 5-6, 5-7 or 6. Anterior oesophagus attached to dorsal retractors by thin mesenteries. Spindle muscle fastened near anus and at posterior extremity of trunk. Contractile vessel simple. One fastener arising from muscle 1 on left side joins last or penultimate spiral of intestine, sometimes giving off a branch to posterior oesophagus. Rectal caecum present. Nephridia, attached to body wall for about half their length, about two thirds as long as trunk and arising at about same level as anus. Brain sometimes observed as slight swelling with two eyespots. Gonads at base of ventral retractors.

Systematic position: The identity of the specimens was discussed by Edmonds (1956, p. 284). They resemble most closely *Phascolosoma scolops* (Selenka and de Man) and to a less extent *Phascolosoma agassizii* Keferstein, two very variable species. Edmonds (1956) considered that they differed from *P. scolops* (1) in the structure of the papillae (they have more uniformly distributed,

more closely set and rounded platelets) and (2) in the possession of a rectal caecum, a structure neither mentioned or figured by Selenka in the type description nor by Sato (1930) nor Wesenberg-Lund (1957) in their descriptions of specimens from Japan and Red Sea. There are two specimens of *P. scolops* in the Nat. Hist. Museum, London, both named and presented by Selenka. No caecum is present in the dissected specimen of the two. Just how important is the presence or absence of a rectal caecum in the systematics of *Phascolosoma* I am not sure. In the circumstances I prefer to specify (with some reservations) the specimens from Western Australia as *P. rottnestii* and not *P. scolops*.

From figs. 3 and 5 of Fischer, 1922 it seems likely his *P. agassizii* from Shark Bay and Rottnest Is. are *P. rottnesti*. I have not, however, been able to find his specimens.

The species is commonly found in limestone rocks, coral and lithothamnion and coralline mats.

Previous Australian record: Western Australia (Edmonds, 1956), ? Fischer, 1919a and 1922.

Distribution: (1) in Australia—Western Australia; as far north as Point Cloates and as far south as Albany. Whether these localities are at the extremities of its distribution is not known.

(2) elsewhere—no records.

Specimens examined and localities: Western Australia—Fremantle (3) "in calcareous rocks near railway bridge" SAM E1367; Rottnest Is. (Wilson Bay) (4) WAM 174/76; Rottnest Is. (Green Is.) (20) WAM 169/76 and (8) SAM E1368; Cottesloe (4) SAM E1369; Pt. Peron (2) WAM 180/76; Garden Is. (1) WAM 234/76; Abrolhos Group at Beacon Is. (2) WAM 237/76 and North Is., "in coral" (2) WAM 241/76; Yallingup Beach (2) AMS W9246; Cheyne Beach, Albany (2) WAM 239/76; Eagle Bay, Cape Naturaliste (2) WAM 174/76; Warroora (1) AMS 5470; Point Cloates (3) SAM E1370.

Phascolosoma scolops (Selenka & de Man)

(Figs 122-3)

Phymosoma scolops Selenka & de Man, 1883, pp. 75-76, figs 17, 138-144; Cutler, 1977, p. 152.

Phascolosoma dunwichi Edmonds, 1956, pp. 292-3, text figs 12-13; Stephen & Edmonds, 1972, pp. 300-301.

Location of type: Not known to author; specimen from Philippines.

Description: Trunk 15-34 mm long and maximum width (in posterior third) 3-6 mm light brown except at anterior and posterior extermities which are dark-brown. Introvert of fixed specimens about as long as trunk with a variable number of dark-brown bands on dorsal surface. Tentacles 15-20 and digitiform, lying in a near ring dorsal to mouth. Surface of introvert just posterior to mouth smooth and collar-like.

Introvert hooks in 15-45 complete and incomplete rows, closely resembling those of *Phascolosoma scolops* as shown in fig 139 of Selenka & de Man (1883). Size of hook may vary in different specimens, smallest being 0·045 mm tall and largest 0·064 mm. Clear streak (running from apex to base of hook) (1) does not always form a uniform arc but may be bent in its middle (much like an Australian boomerang) and (2) is sometimes expanded at or just below bend. Most hooks with a small "secondary tooth", something not shown in Selenka's fig 139. A clear triangular area present on one side of clear streak at base of hook but lacking the clear crescentric area as found in *P. stephensoni*.

Papillae between hooks small, flat, circular to elliptical with diameter 0·02-0·03 mm. Papillae at base of introvert darker, concical (sometimes sharply) to hemispherical, consisting of an apical pore surrounded by almost contiguous, polygonal plates of about equal size. Papillae on trunk largest and most closely packed at anterior and posterior extremities, particularly on dorsal side; 0·2-0·35 mm tall and 0·2-0·3 mm wide. Papillae in mid-trunk region smaller, more scattered and less pointed. In some specimens number of papillae on middle and posterior surfaces may be reduced.

Longitudinal muscles in 20-25 anastomosing bands often clearly visible through body wall. Four retractors, a stout ventral pair attached to muscles 2-7, 1-6 or 2-6 in posterior half of trunk and a more slender dorsal pair more anteriorly to muscles 6-7, 5-7 or 6-8. Retractors on each side fuse anteriorly. One fastener runs from muscle 1 near base of left dorsal retractor to last spiral of intestine, sometimes giving a root to posterior oesophagus. Wing muscle well-developed. Spindle muscle fastened anteriorly near anus and posteriorly to body wall. Rectal caecum not present. Contractile vessel simple. Nephridia brown, about quarter to half as long as trunk, fixed for about half their length and opening at about same level as anus. Two eyespots present.

Systematic position: Edmonds (1956, p. 292) identified some specimens from Dunwich as *P. dunwichi* a new species allied to *P. scolops*. The main differences were that *P. dunwichi* possessed a caecum and that there were some differences in the size and distribution of the platelets of the papillae. More recently I have re-examined the specimens and consider that a caecum is not present. I must have mistaken a small outpocketing of the gut wall

containing some hard food particles for a caecum. In addition the size and distribution of the platelets of some of the newer specimens in my collection approach more closely those of the two specimens of *P. scolops* (named by Selenka) now in the Natural History Museum, London. The differences then between *P. scolops* and *P. dunwichi* then become insignificant and the latter becomes a junior synonym of the former.

What the distribution of the species is in Australia is not known. Very few phascolosomatids from northern and north-western Australia are available for study. However, all the specimens of *P. rottnestii* from south-west Australia that I have examined do possess a well-developed caecum.

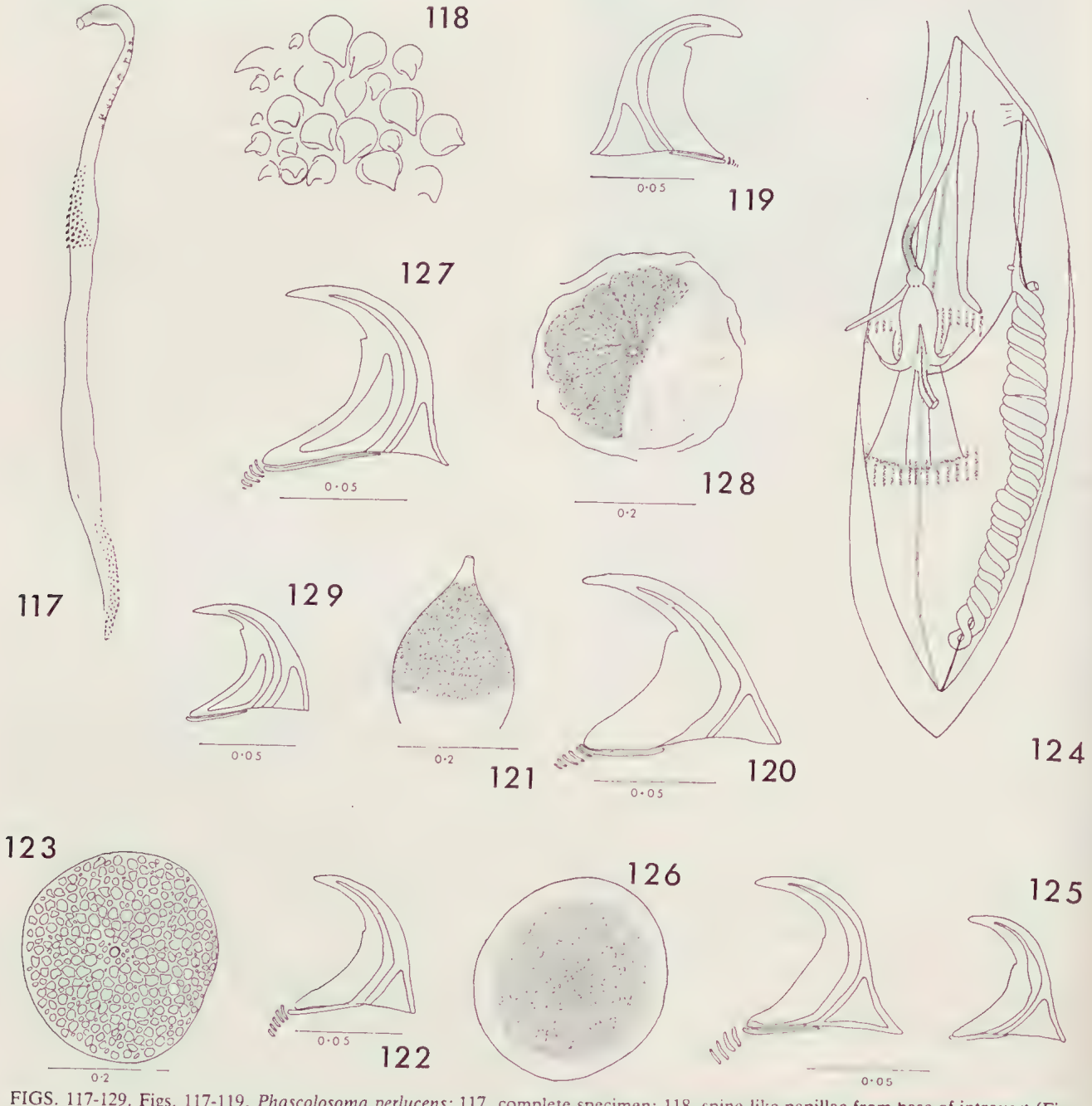
Superficially *P. scolops* and *P. stephensoni* are almost indistinguishable. The crescentic-shaped clear area present on the hook of *P. stephensoni*, however, is not present in *P. scolops*.

Previous Australian records: Queensland—Edmonds (1956); Monro (1931). Cutler (1977) reports one specimen off South Australia.

Distribution: (1) in Australia—Queensland.

(2) elsewhere—widely reported from the Indo-Pacific.

Specimens examined and localities: Queensland —Dunwich (on Stradbroke Is.) (1) in clumps of mussels SAM E1339; (3) SAM E1340; (6) SAM E1341.



FIGS. 117-129. Figs. 117-119, *Phascolosoma perlucens;* 117, complete specimen; 118, spine-like papillae from base of introvert (Figs. 117 & 118 after Fisher); 119, introvert hook. Figs. 120-121, *Phascolosoma pacificum;* 120, introvert hook; 121, papilla from introvert. Figs. 122-123, *Phascolosoma scolops;* 122, introvert hook; 123, trunk papilla. Figs. 124-126, *Phascolosoma rottnesti;* 124, dissected specimen; 125, introvert hook; 126, trunk papilla (same scale as Fig. 123). Figs. 127-129, *Phascolosoma stephensoni;* 127, introvert hook; 128, trunk papilla; 129, hook from one of Stephen's specimens.

Phascolosoma (Pascolosoma) stephensoni (Stephen)

(Figs 127-129)

Physcosoma stephensoni Stephen, 1942, p. 250, pl. 11, figs 3-5.

Phascolosoma stephensoni: Wesenberg-Lund, 1963; pp. 121-126, text figs 7-9.

Phascolosoma heronis Edmonds, 1956, pp. 293-295, fig. 14.

Physcosoma scolops: Monro, 1931, p. 31.

? Physcosoma agassizii: Fischer, 1922, p. 7, pl. 1, fig. 6.

Location of type: Royal Scottish Museum, Edinburgh; specimen from Natal, South Africa.

Description: This account is based on the specimens below and a collection from Hawaii (SAM E1176). Trunk slender, 1·5-3·5 mm long and pale-straw to flesh coloured. Introvert of fixed animals about as long as trunk, with 5-9 brown to red-black bands of variable width on its dorsal surface. Closely packed pigmented papillae make base of introvert darker than surface of trunk. Rust coloured patches present in some places on trunk. Trunk of some Hawaiian specimens uniformly pale although some large papillae present posteriorly.

Introvert with almost complete ring of 20-24 digitiform tentacles lying dorsal to mouth and with a smooth, collar-like region just posterior to mouth. Introvert hooks in many complete and incomplete rows may vary in size even when taken from same animal, those more posteriorly placed being smaller. Hook always possesses a clear streak (running from apex to base), a clear crescentic area on one side of streak and a clear triangular area on other, a small secondary "tooth" and 4-6 bars basi-laterally. Rings of very small, subconical papillae, 0·02-0·04 mm tall and 0·025-0·05 mm wide basally, lie between rows of hooks.

Trunk papillae at posterior extremity of trunk usually conical, 0·3-0·5 mm tall and 0·25-0·4 mm wide basally, but sometimes a more rounded form is present as well. Conical form covered with small, brown polygonal plates but rounded form lacking small plates and possessing a number of curved petal-like plates radiating from an apical pore. It is possible that the rounded type is the result of the loss of the outer polygonal plates from the conical type. Papillae on dorsal surface largest. Mid-trunk papillae smaller, hemispherical, less pigmented and more scattered.

Longitudinal muscles in 20-25 anastomosing bands. Four retractors, a stouter ventral pair attached to muscles 1-5, 2-6, 2-7 or 2-8 near middle of trunk and a more slender dorsal pair more anteriorly to 5-8, 6-7 or 6-8. One fastening muscle, attached to muscle 1 near base of left dorsal retractor, runs to last spiral of intestine, sometimes giving off a small root to posterior oesophagus. Rectal caecum present (dissected specimens SAM E1373 and E1531). Stephen in the type description did not mention the presence or absence of the structure. Wesenberg-Lund (1963, p. 124) states with emphasis that no rectal caecum is present. Dr. G. Smaldon (Royal Scottish Museum), however, informs me (personal communication) that a caecum is present in Stephen's dissected holotype. Contractile vessel without villi. Nephridia, about a third as long as trunk and fixed for about half their length, arise at about same level as anus.

Systematic position: *P. heronis* was described by Edmonds (1956) from some specimens collected at Heron Is. in the Capricorn Group, Queensland. Wesenberg-Lund (1963, p. 126) pointed out that the hooks of *P. heronis* closely resembled those of *P. stephensoni* (Stephen, 1942) from South Africa. Through the kindness of the Trustees of the Royal Scottish Museum I have been able to examine three of Stephen's specimens from Inhaca, Mozambique (1960.48.14), one a dissected specimen. I now consider that the two species are conspecific, Stephen's having priority. The hooks of the South African and Australian specimens are the same, although slightly different in size, and the papillae of Stephen's specimens are covered with fine plates, something not mentioned by him but reported for her South African specimens by Wesenberg-Lund (1963). I am grateful to the late Dr. Wesenberg-Lund for her observations. *Phascolosoma heronis* must be sunk.

It seems most likely that Fischer's (1922) record of *P. agassizii* from "Port Jackson near Sydney" is that of *P. stephensoni;* the drawing of the hook (pl. 1, fig 6) matches that of the latter species. Fischer's fig 6, however, in my opinion, differs from the books of *P. agassizii* as shown in plates 37 and 38 of Fisher, 1952. What I am now calling *P. stephensoni* is widely distributed in the Pacific Ocean. I have specimens from Hawaii, New Hebrides, Solomon Is., and Fiji. It is puzzling to know what name has been given to such specimens previously. I do not think that they are *P. scolops* because a re-examination of two specimens named by Selenka himself and now lodged in the British Museum (Nat. Hist) shows that the hooks lack the clear, crescentic area which is so prominent in *P. stephensoni.* The introvert hook of *P. fasciatum* Baird, 1868 as shown in fig 17 of Rice & Stephen (1970) also possesses a clear crescentic area. The current name of *P. fasciatum* is *P. granulatum* (Leuckart). I consider, however, that the hook of

these Australian specimens does not match that of *P. granulatum* as shown in Selenka & de Man (1883, fig 147).

Stephen considered that the distribution of *P. stephensoni* was localised along the coast of Natal (Wesenberg-Lund, 1963 p. 126). The occurrence of the species in Australia, Norfolk Is., Hawaii, etc. shows that its range is Indo-Pacific. What is difficult to account for is that it has not yet appeared anywhere else in the Indian Ocean nor on the western coast of Australia. In Australia, Hawaii and the Solomon Is. it is usually associated with coral formations.

The species differs from closely related species in the markings on its hooks.

Previous Australian record: Queensland—Heron Is., Low Is. (Edmonds, 1956).

Distribution: (1) in Australia—Queensland; New South Wales; Norfolk Is., Lord Howe Is.

(2) elsewhere—South Africa; Hawaii (SAM E1376-7); Solomon Is.

Specimens examined and localities: Queensland —Caloundra (5) SAM E1372 and (1) AMS W19550; Low Is. (3) SAM E1374; Albany Passage (North Queensland) (2) AMS G11224; Heron Is. (3) AMS W3597 (includes type of *P. heronis*) and (2) WAM 150/76; Norfolk Is. (2) SAM E1378. New South Wales—off Coff's Harbor (10) SAM E1373; Minnie Waters (2) AMS W9247; Lennox Head (6) AMS W10552; Arrawarra (2) AMS W10555; Lord Howe Is. (2) SAM E1375; Lord Howe Is. (Salmon Beach) (6) SAM E1531.

FIG. 130. Distribution of Sipunculidae in Australia.

FIG. 131. Distribution of Golfingiidae in Australia.

FIG. 132. Distribution of Aspidosiphonidae in Australia.

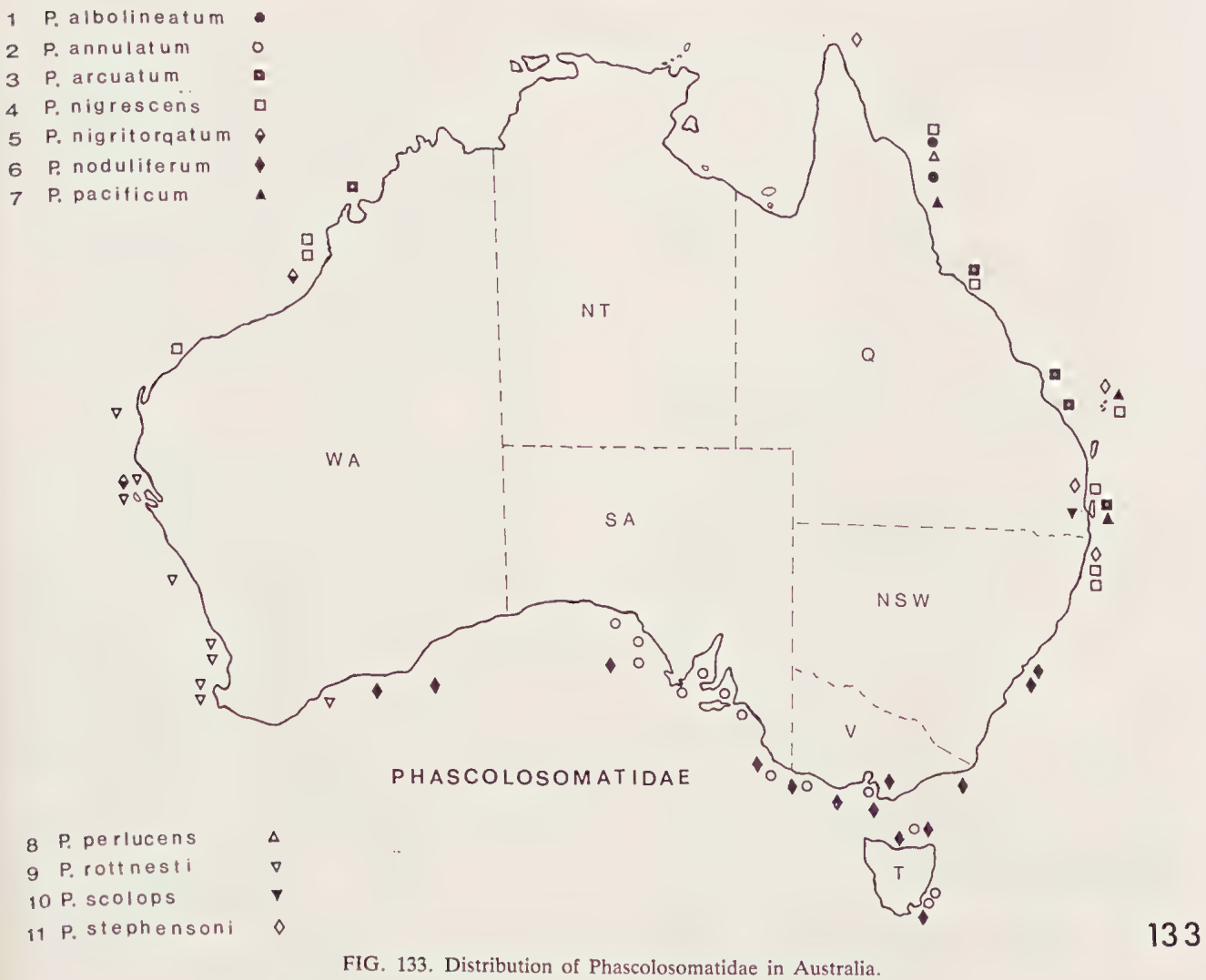


FIG. 133. Distribution of Phascolosomatidae in Australia.

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THE DISTRIBUTION IN AUSTRALIA OF THE GRASS BUGS OF THE TRIBE STENODEMINI (HETEROPTERA-MIRIDAE-MIRINAE)

NATIONAL MUSEUM
18 AUG 1980
OF VICTORIA

by

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ABSTRACT

CARVALHO, J. C. M. & GROSS, G. F., 1978. The distribution in Australia of the grass bugs of the tribe Stenodemini (Heteroptera-Miridae-Mirinae) *Rec. S. Aust. Mus.* 18(2): 75-82.

The Stenodemini are represented in Australia by the three genera and species, *Dolichomiris linearis* Reuter, 1882, *Chaetedus longiceps* Eyles, 1974 and *Trigonotylus doddi* (Distant, 1904).

A key is provided to separate these three species and figures and a brief diagnosis of each are given to further assist in their recognition. Their known distribution in Australia is plotted on a map, and in the case of the two less common species *Dolichomiris linearis* and *Chaetodus longiceps*, new records to hand since the Eyles (1975) and Eyles & Carvalho (1975) revisions of the group are given in detail.

INTRODUCTION

The authors have in preparation a series of papers in which we shall attempt to give as complete an account of the species of Miridae and their distribution in Australia as is possible on the material to hand in collections, with the exception of the Bryocorinae and the non-mimetic Phylini which have been entrusted to other authors.

In the paper which immediately preceded this (*Rec. S. Aust. Mus* **17** (30): 000-000), though covering the tribe Hyalopeplini of the subfamily Miridae on a world basis, we were able to include all records and specimens of Australian material of that group.

This paper deals with the allied tribe Stenodemini in Australia, but it has been purposely kept short as there have been two other recent contributions (*vide infra*) on the taxonomy and distribution of the Stenodemini in this general region.

Tribe Stenodemini

A small group of Miridae which was raised to tribal rank in the subfamily Mirinae by China (1943). This placement and ranking was accepted by Carvalho (1952 and subsequent papers). The group has subsequently been lowered to an unstated rank in the Mirinae by Schuh (1976) as a consequence of his demotion of the subfamily Mirinae *sensu* Carvalho to a tribe of an enlarged subfamily Mirinae. However, we propose to retain the group at its former rank for the time being.

The principal characters which taken together distinguish this group from other Mirinae (*sensu* Carvalho, or Mirini *sensu* Schuh) are a rather delicate appearance with the first segment of hind tarsi longer than (or as long as) the second and third together, the antennae and legs relatively long and the pronotal collar incomplete.

The group are grassfeeders, their elongate and delicate shape presumably playing a role in camouflage. Their small size and delicate stature, as with a number of other Heteroptera of similar size and shape (c.f. *Nabis* species), appear to have helped them to be very vagile. They are known from all zoogeographic regions with a number of genera (e.g. *Acetropis* Fieber, *Collaria* Provancher, *Dolichomiris* Reuter, *Leptopterna* Fieber, *Megaloceroea* Fieber, *Stenodema* Laporte de Castelnau, *Teratocoris* Fieber and *Trigonotylus* Fieber) and species (e.g. *Dolichomiris linearis* Reuter, *Leptopterna dolobrata* (Linnaeus), *Megaloceroea recticornis* Geoffroy, *Stenodema trispinosum* Reuter, *Stenodema laevigatum* (Linnaeus), *Stenodema virens* (Linnaeus), *Teratocoris saundersi* Douglas & Scott, *Teratocoris viridis* Douglas & Scott, *Trigonotylus doddi* (Distant) and *Trigonotylus ruficornis* (Geoffroy)) widespread in two or more zoogeographic regions. The group is represented in Australia by three genera and species, two of the species and their genera are widespread, the third species is endemic to Australia and New Zealand and belongs to a genus *(Chaetedus)* known only from the Australian, Papuan and New Zealand regions. As Eyles (1975) and Eyles and Carvalho (1975) have recently reviewed these genera and species we give here only a summary account of the Australian species. However, the distribution of the three species which occur in Australia is much more extensive than the above authors realised, so we have mapped all locality records now available, but have cited in detail further records only of the two less common species.

The three Australian species may be separated as follows:—

Key to Australian Stenodemini

1. First antennal segment and base of second covered by long erect pubescence, hairs as long as or longer than, width of segments; first antennal segment as long as from its insertion to base of pronotum
Dolichomiris linearis Reuter, 1882.

All antennal segments with only short pubescence, hairs shorter than half width of segments; first antennal segment much shorter than distance from its insertion to base of pronotum 2

2. First antennal segment much longer than head; second antennal segment with dark, bristle-like hairs near base; ratio of length: width pronotum at base about 45:60; body length in range 5·2-8·7 mm
Chaetedus longiceps Eyles, 1974

First antennal segment about as long as head; second antennal segment without dark, bristle-like hairs; ratio length: width pronotum about 20:33, body length in range 3·7-6·6 mm ..... *Trigonotylus doddi* (Distant, 1904)

Dolichomiris Reuter, 1882

Dolichomiris Reuter, 1882, p. 29. Additional references and synonymy by Eyles & Carvalho, 1975, pp. 258, 267.

Type-species: *Dolichomiris linearis* Reuter, 1882. For the type-species of synonymous genera see Eyles & Carvalho *opp.cit.*

Body elongate and slender, smooth or very finely punctured. Head horizontal, clypeus large and visible from above, vertex sulcate between eyes which touch or nearly touch pronotum. Antennae long, segments I and II (at least basally) with long, fine, erect, hairs which are at least as long as half width of segment.

Pronotum with calli flat, smooth or very finely punctured, collar depressed and weakly marked, lateral margins carinate. Scutellum flat, smooth or very finely punctate. Hemelytra smooth or very finely rugose; cuneus distinctly longer than wide. Legs long, hind tibiae covered with long, erect hairs. Aedeagus with two spiculi.

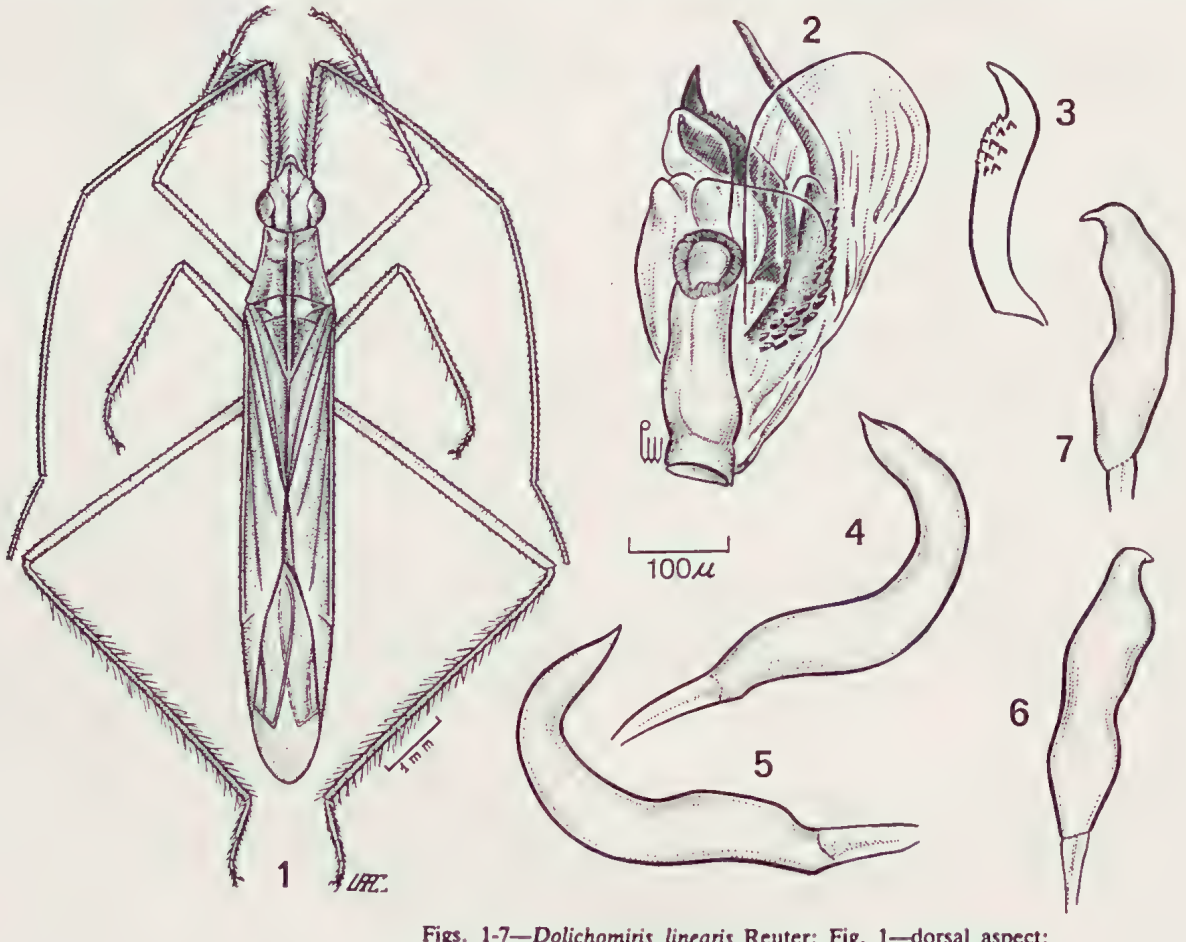
Remarks: Only the type-species occurs in Australia.

Dolichomiris linearis Reuter, 1882
(Figs. 1-7, 16)

Dolichomiris linearis Reuter, 1882, p. 29. Additional references and synonymy by Eyles and Carvalho, 1975, pp. 258, 260-2 and by Carvalho and Wallerstein, 1976, pp. 511-515.

Location of type: Lectotype ♂ in the Zoological Museum of the University, Helsinki.

Colour: A faint, iridescent, pale brown with a dark, reddish longitudinal stripe on head and a pale, median longitudinal stripe on pronotum and scutellum which is margined with light red. Eyes grey, some red longitudinal marks laterally on head and thorax, hind femora tending reddish brown.



Figs. 1-7—*Dolichomiris linearis* Reuter: Fig. 1—dorsal aspect; Figs. 2-7—male genitalia; Fig. 2—vesica; Fig. 3—small spiculum; Fig. 4-5—two aspects of left paramere; Figs. 6-7—two aspects of right paramere.

Structure: Very elongate; membrane considerably surpassing apex of abdomen, hind femora not as long as hemelytra. Long and erect hairs on antennae restricted to first segment and base of second; second and third antennal segments very long.

Male genitalia: Pygophore with a tooth on left hand side near upper corner, vesica (fig. 2) with two spiculi, each with small sclerotized teeth (fig. 3). Left paramere (figs. 4-5) falciform, tapering to apex. Right paramere (figs. 6-7) smaller, constricted medially, apex curved and pointed.

Length: 7·3-9·0 mm.

Distribution: Almost cosmopolitan, ranging from southern Europe through east and west Africa, the Canary Islands, Madeira, North, Central and South America, the Galapagos Islands, India, Ceylon, Burma, Java, Sumba, New Guinea, Queensland, the New Hebrides, New Caledonia (new record) and Fiji.

Specimens examined: AUSTRALIA-Queensland 2♂♂ Redlynch, 31.viii. 1938, *ex* E.P. Van Duzee collection May 1934, A. R. Brimblecombe; 2♂♂, Running Creek, 15.iv. 1941, A. W. Smith, all in DPIQ; 1♂, Rockhampton, 13.vii. 1960, C. N. Smithers, AM; 1♂, 14 km (9 mi.) n of Dayboro, 23.iv.1966, Z. Liepa, ANIC. These new localities together with those of Eyles and Carvalho (1975) have been plotted on fig. 16.

In addition we have examined material from the following new localities outside of Australia. NEW CALEDONIA—1♂ 1♀, Mt. Ouen Toro, 19.ix.1962, G. F. Gross; 1♀, by sweeping roadside vegetation, 3 km. s of Touho, 10.x.1962, G. F. Gross, all in SAM. NEW HEBRIDES-*Efate,* 1♂, 1♀, at light, Vila, 11 and 12.vii.1971, G. F. Gross on Royal Society-Percy Sladen Expedition; Erromanga, 1♂ 1♀ Ipotak, 5.viii.1971, G. F. Gross on Royal Society-Percy Sladen Expedition, all in SAM. FIJI *Viti Levu,* 1♀, sweeping and beating herbs and shrubs, Nandarivatu, 800 m (2700 ft.), 10.xi.1964, N. McFarland; 1♀, Nagatosota Village, 1.ix.1976, J. A. Herridge SAM.

Remarks: According to Eyles and Carvalho (1975) *Dolichomiris linearis* is more slender and more delicate looking than other species of *Dolichomiris* and has only a very finely punctate pronotum.

Chaetedus Eyles, 1975

Chaetedus Eyles, 1975, p. 155-6; Eyles & Carvalho, 1975, p. 268.

Type-species: *Megaloceroea reuteriana* White, 1878. O.D.

Body elongate and slender, smooth with pronotum dorsally finely punctured. Head horizontal, clypeus large and visible from above; frons striate, vertex sulcate between eyes which do not touch anterior margin of pronotum. Antennae long, segments I and II (at least basally) with short, bristle-like, dark hairs which are not as long as width of segment.

Pronotum with calli flat, finely punctate except on calli, collar depressed and weakly marked, lateral margins thickly carinate except anteriorly. Scutellum nearly flat. Hemelytra smooth or very finely rugose, cuneus longer than wide. One of two spiculi of aedeagus hooked, serrate or plumose.

Remarks: *Chaetedus* Eyles has four species, *reuterianus* (White) is restricted to New Zealand, *longiceps* Eyles occurs in both Australia and New Zealand, *plumalis* Eyles in Norfolk and the Raoul Islands and *rutilans* Eyles in New Guinea.

Chaetedus longiceps Eyles, 1975

(Figs. 8-16)

Chaetedus longiceps Eyles, 1975, pp. 156-7, 162.

Location of type: Holotype ♂ and allotype ♀ in Entomology Division, DSIR, Auckland, New Zealand.

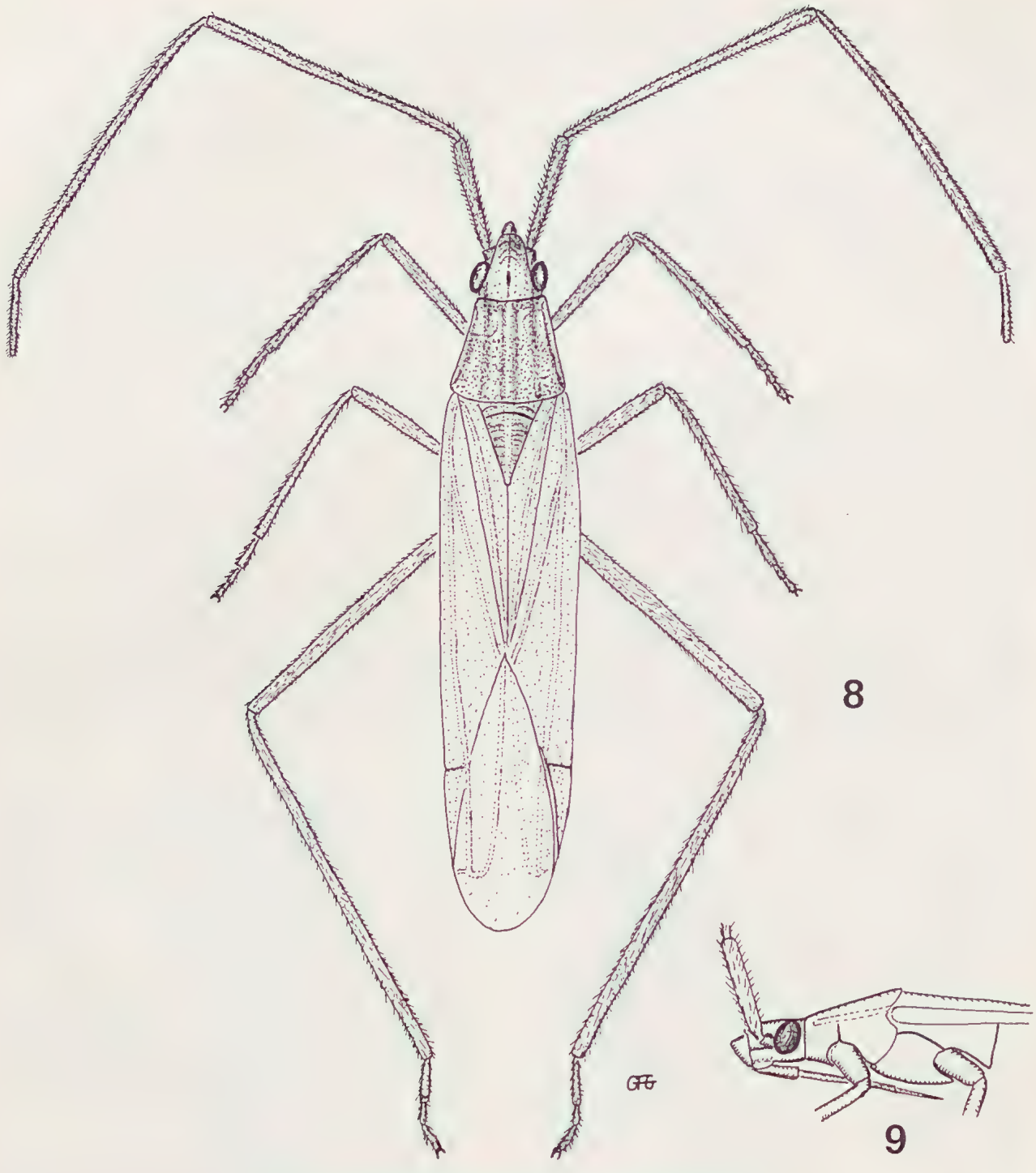
Colour: Fresh specimens green but later fading to stramineous. Eyes grey. Antennal segments II to IV red or suffused with reddish. pronotum with four longitudinal dull stripes between inner stripes pale. Scutellum with two longitudinal, dull stripes between these paler. Apices of tibiae and tarsi red or suffused with reddish.

Structure: Second and third antennal segments equal in length and each about three times as long as first, fourth equal in length to first. Scutellum faintly strigose on either side of midline. Hemlytra longer than hind femora, membrane considerably surpassing apex of abdomen.

Male genitalia: Pygophore (figs. 10-11) with a conical process on left side; vesica (fig. 12), both spiculi sclerotized with the usual plumosity on one reduced to minute teeth (fig. 13). Left paramere (fig. 14) falciform and tapering to apex pointed and curved apically. Right paramere (fig. 15) pointed apically.

Length: 6·8-8·1 mm.

Remarks: Species of this genus were formerly thought to be all *Megaloceroea reuteriana* White until Eyles (1975) showed that four species were present in our general region and belonged to a new genus which differes from *Megaloceroea* Fieber in, *inter alia,* having the first antennal segment distinctly

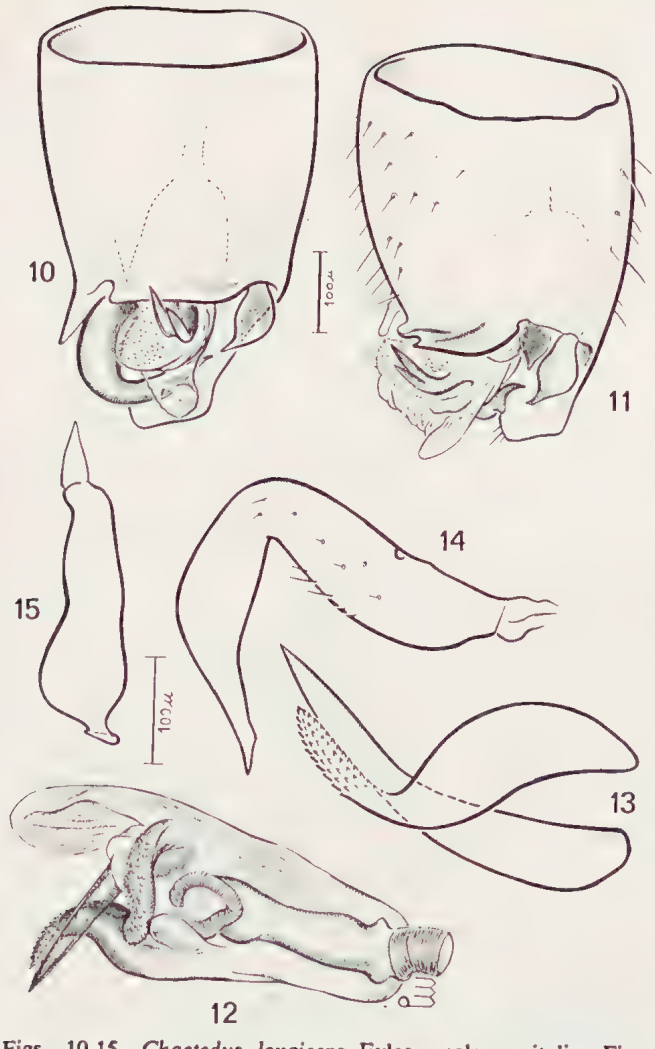


Figs. 8-9—*Chaetedus longiceps* Eyles: Fig. 8—dorsal aspect; Fig. 9—lateral view of head and thorax.

shorter than the head and pronotum together and one of the spiculi of the aedeagus, hooked, serrate or feathery. *Chaetedus reuterianus* and *C. longiceps* are green in life whereas the two species with a more tropical distribution, *plumalis* and *rutilans*, are reddish. *C. reuterianus* has a prominent, red, lateral abdominal stripe which is absent in *longiceps*.

Distribution: New Zealand and Southern Australia, including Tasmania.

Specimens examined: AUSTRALIA: New South Wales, 1♂, Oxford; 31.xii.1962, D. K. McAlpine; 1♂, 1♀, Mt. Gibraltar National Park, 24.ii.1965, D. K. McAlpine, all in AM; ♂ Rydalmere, at Mercury vapour light, 15.x.1971; Broadwater NSWDA. A.C.T. 1♀, Canberra, 27.iii.1959, G. E. Chadwick, NSWDA. Victoria 1♀, Glen Waverley, sweeping Gramineae and Compositae in garden, 19-31.xii.1976, J. J. H. Szent-Ivany. South Australia, 3♀♀, Mylor, Nov. 1949, G. F. Gross, SAM. Western Australia, 1♀, Walpole-Nornalup National Park (35° 00′S, 116° 49′E) at The Knoll, 11.xi.1969, E. B. Britton, ANIC. These localities and those of Eyles (1975) for Australia are plotted on fig. 16.



Figs. 10-15—*Chaetedus longiceps* Eyles, male genitalia: Fig. 10—ventral aspect of pygophore; Fig. 11—lateral aspect of same; Fig. 12—vesica; Fig. 13—sclerotized spiculum; Fig. 14—left paramere; Fig. 15—right paramere.

Trigonotylus Fieber, 1858

Trigonotylus Fieber, 1858, p.302. Other references and synonymy in Eyles, 1975, pp. 153, 162.

Type-species: (of *Trigonotylus*) *Miris ruficornis* Fallen, 1807 (=*Cimex ruficornis* Geoffroy in Fourcroy, 1785) O.D.

Smallish and elongate, pronotum punctate. Head horizontal, clyqeus large and visible from above, frons usually prolonged over base of clypeus, vertex sulcate medially between eyes, eyes touching pronotum. Antennae long, first segment not as long as head and pronotum together, without black bristle-like hairs.

Pronotum depressed laterally, collar depressed and weakly marked, calli flat, lateral margins carinate. Scutellum flat and smooth. Hemelytra smooth and glabrous, cuneus distinctly longer than wide. Legs relatively long. Aedeagus with a single spiculum, or spiculi lacking.

Remarks: Only the one cosmopolitan species is represented in Australia. The genus was last revised by Carvalho and Wagner 1957.

Trigonotylus doddi (Distant, 1904)

(Figs. 16-24)

Megaloceroea doddi Distant, 1904, p. 269; other references and synonymy in Eyles 1975, pp. 162-4.

Location of type: Lectotype ♂ in British Museum (Natural History).

Colour: Fresh specimens green but later fading to stramineous. Eyes grey. Antennae suffused with pink. Pronotum and scutellum with a pale median stripe bordered by a pale brown or red stripe on each side, on pronotum on each side are additional fainter brown or red stripes between the median stripes and lateral margin. Apex of hind tibia, first two tarsomeres and base of third of hind leg red, claw and apex of last tarsomere of hind leg black. Corium paler between veins R and M and costal margin. Beneath lateral margins sometimes reddish.

Structure: Second antennal segment a little longer than third and both about three times as long as first, fourth a little shorter than first. Hemelytra longer than hind femora, membrane considerably surpassing apex of abdomen.

Male genitalia: Pygophore (figs. 54-55) with a conical spinous process on left side; aedeagus (fig. 56) with membranous lobes and one sclerotized spiculum. Left paramere (figs. 57-58) falciform with apex tapering and sinuate, right paramere (fig. 59) small with a spinous apical process.

Length: 4·2-5·7 mm.

Remarks: This is much the most common and widespread of the three Stenodemini species in Australia and differs from *Dolichomiris linearis* and *Chaetedus longiceps* in its much smaller size and very much shorter first antennal segment.

Distribution: Widely distributed mainly in tropical and subtropical areas but in New Zealand and Australia extending into the temperate zones and in the latter also into the arid regions. *Trigonotylus doddi* has not been recorded from Tasmania, New Caledonia, New Hebrides, Polynesia east of the Gilbert and Kermadec Islands, Solomon Islands, New Guinea or Indonesia. We have seen material from the Cocos, Keeling and Fijian Islands from which there were no previous records.

Specimens examined: 7 ex Department of Primary Industries, Queensland; 9 ex QM; 10 ex ANIC; 4 ex AM; 15 ex New South Wales Department of Agriculture; 2 ex NM; 69 ex SAM; 1 ex Western Australian Department of Agriculture; 1 ex Zoological Museum of the University, Helsinki.

As this species is now known to be widespread in Australia we have not listed all the localities in detail but have plotted the Australian records of Eyles 1975 and all the additional material we have examined on the map on figure 16.

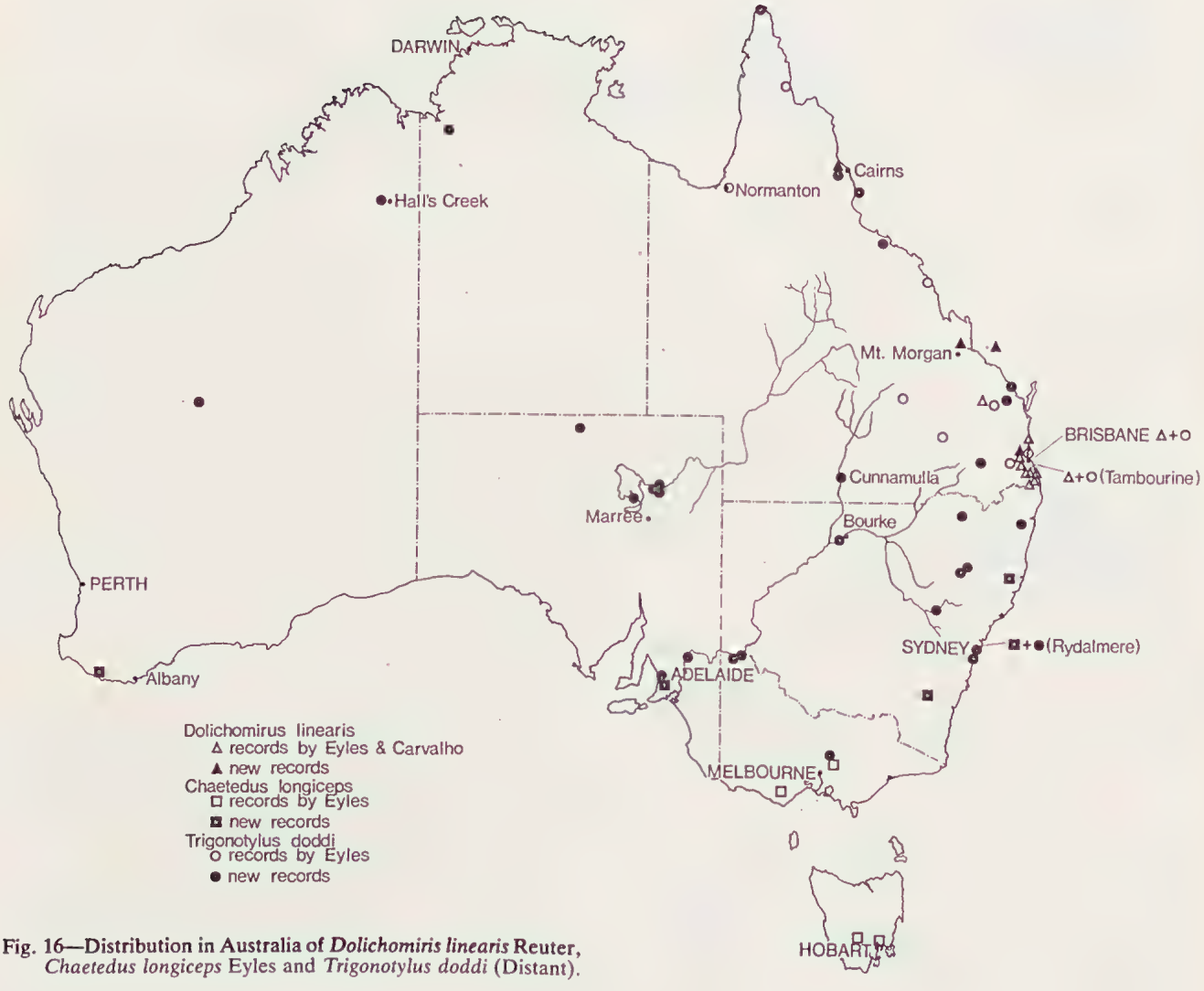
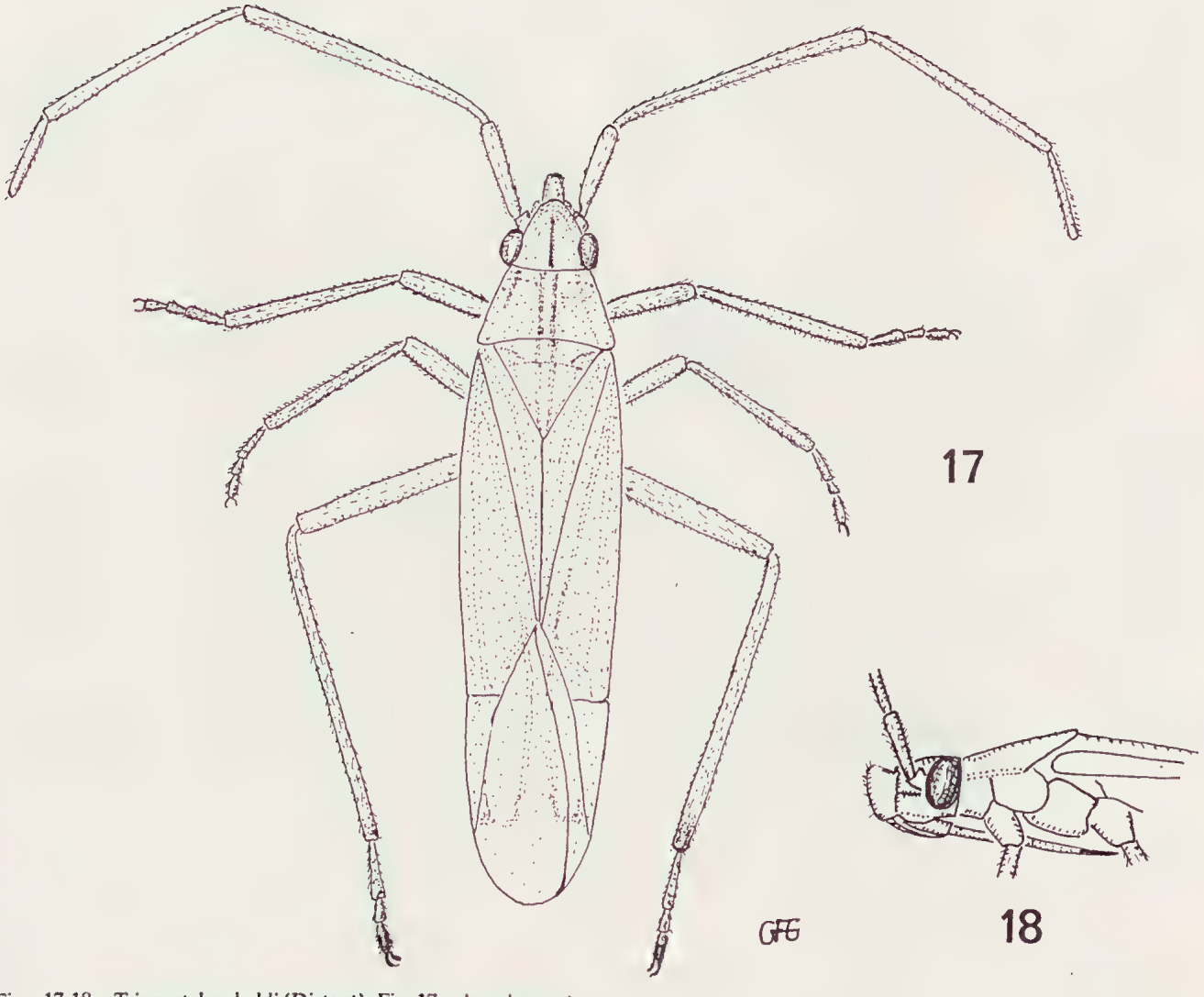
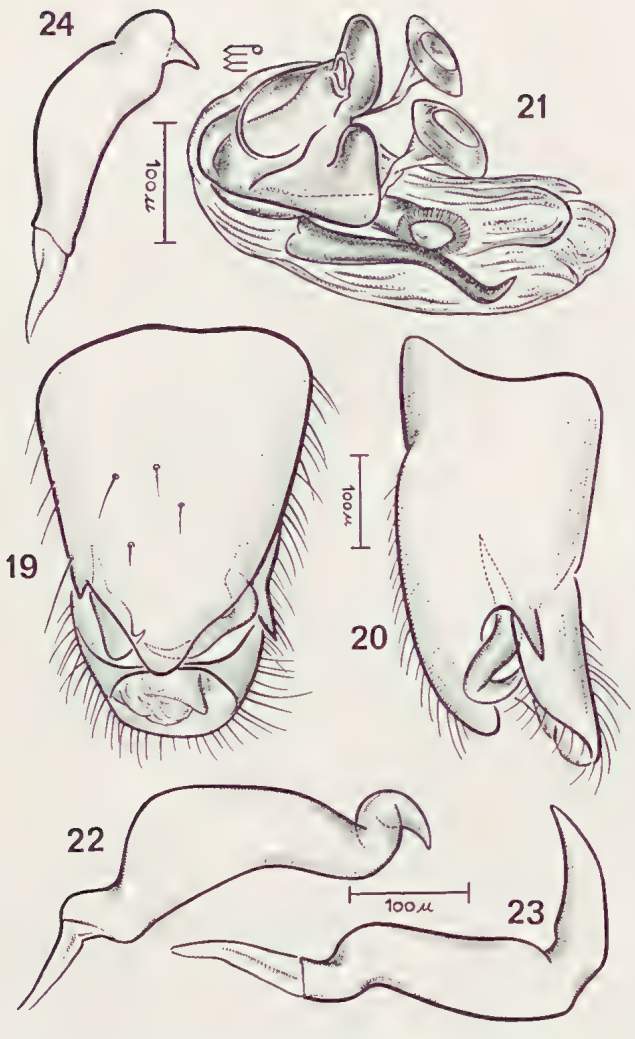


Fig. 16—Distribution in Australia of *Dolichomiris linearis* Reuter, *Chaetedus longiceps* Eyles and *Trigonotylus doddi* (Distant).



Figs. 17-18—*Trigonotylus doddi* (Distant): Fig. 17—dorsal aspect; Fig. 18—lateral view of head and thorax.



Figs. 19-24—*Trigonotylus doddi* (Distant) male genitalia: Fig. 19—ventral aspect of pygophore; Fig. 20—lateral aspect of pygophore; Fig. 21—aedeagus and vesica; Figs. 22-23—two aspects of left paramere; Fig. 24—right paramere.

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TWO NEW GENERA OF THE SUBFAMILY PENTATOMINAE (HETEROPTERA: PENTATOMIDAE) FROM THE AUSTRALIAN REGION[1]

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18 AUG 1980

by

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ABSTRACT

AHMAD, I., & KHAN, N. A. 1979. Two new genera of the subfamily Pentatominae (Heteroptera:Pentatomidae) from the Australian region. *Rec. S. Aust. Mus.* **18**(3): 83-90.

Two new genera, *Grossiana* and *Knightiella*, are described to accommodate *Strachia persignata* Walker and *Stenozygum flavifrons* Distant known from Queensland and New Caledonia respectively. The above species are redescribed, the characters of their metathoracic scent gland ostioles and male and female genitalia are described for the first time and their position in the subfamily Pentatominae is briefly discussed.

INTRODUCTION

Strachia persignata Walker, 1867 and *Stenozygum flavifrons* Distant, 1914 were described from Queensland and New Caledonia respectively in the Australian region. During a revision of *Stenozygum* Fieber, 1861 from the Oriental and Australian regions by the present authors the above species were compared with the type-species of the genus and with all the Oriental and Australian species described under the genera *Strachia* Hahn, 1833 and *Stenozygum* and were found to be very different, especially in the characters of metathoracic scent gland ostioles and male and female genitalia. These two species are redescribed here with special reference to the above-mentioned characters and placed each in a new genus, *Grossiana* and *Knightiella* respectively. Their position in the family is briefly discussed. For the dissection of male and female genitalia, for measurements and diagrams the conventional procedures, especially those of the present authors (in press) have generally been followed.

Genus GROSSIANA New Genus

Body brilliantly patterned.

Head: Eyes stalked; basal antennal segments uniformly thick and slightly inwardly curved, distinctly passing beyond apex of head; labium reaching posterior coxae.

Thorax: Metathoracic scent gland ostioles without peritreme and with ill-defined evaporatoria.

Male genitalia: Pygophore with latero-posterior lobes distinct but not detached or marked from the rest of the pygophore; parameres simple, sickle-shaped; inflated aedeagus with vesica distinctly shorter than penial lobes and apically semi-sclerotized, dorsal membranous conjunctival appendage, and ventral conjunctival appendage fully membranous.

Female genitalia: Female terminalia with triangulin visible in between 1st gonocoxae, with ends pointed and reaching to inner anterior margin of 1st gonocoxae, spermatheca without processes on spermathecal bulb.

Comparative note: Grossiana is somewhat closely related to *Strachia* in having the basal antennal segment long and surpassing apex of head and second antennal segment subequal to third, but it can easily be separated from all the species of that genus in having a simple unilobed pronotum as opposed to distinctly laterally bilobed in the species of *Strachia* and in other characters noted under "Systematic positions".

The genus is named in honour of Dr. G. F. Gross of South Australian Museum, Adelaide, Australia to acknowledge his work on Heteroptera.

Type-species: Strachia persignata Walker, 1867.

Grossiana persignata (Walk.)

(Figs. 1-10)

Strachia persignata Walker, 1867, p. 347.

Stenozygum persignatum Distant, 1881, p. 213.

Coloration: Body shining black with prominent yellow markings (fig. 1), uniformly punctured except head and anterior portion of pronotum; ventrally yellow with a small black patch in the middle on either side along the margins of bucculae, a small black spot at the base of antenniferous tubercles on either inner side, broad black longitudinal lines on outer portion of pro-, meso-, and metapleuron, on either side, black punctures on the rest of pro-, meso-, and metapleuron, dark brown 2nd, 3rd and 4th segments of labium, a black transverse patch posterior to spiracles on 2nd-7th abdominal segments and a black transverse patch on outer portion along the lines between 2nd-7th abdominal segments on either side.

[1] Financially supported by an ARC-USDA Research Project A17-ENT-37, (FG-Pa-181).

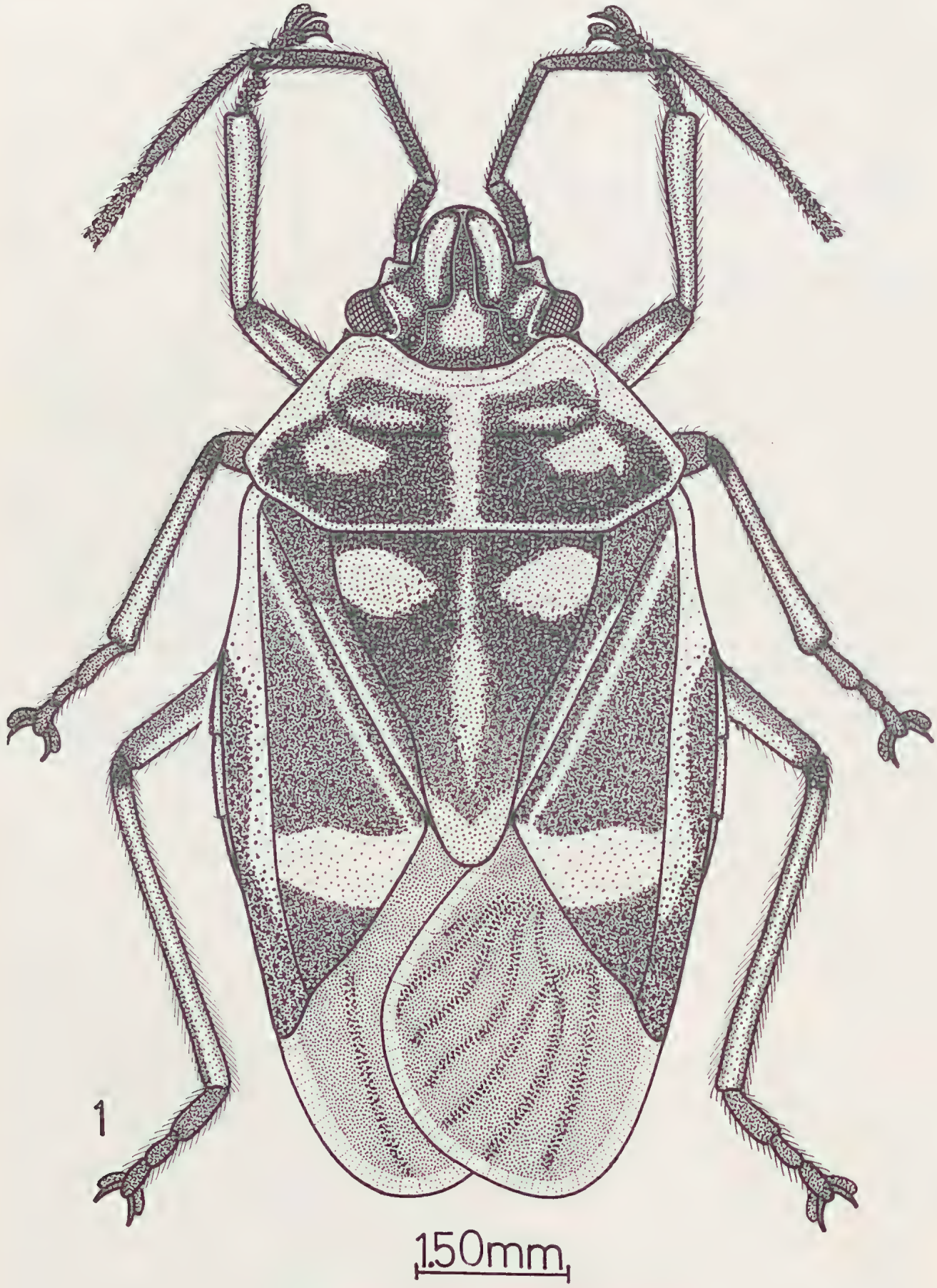


Fig. 1—*Grossiana persignata* (Walker) female, dorsal view.

Head: Anteocular portion equal to the posterior portion of head including eyes, length of anteocular portion 0·75 mm, length of posterior portion of head including eyes 0·75 mm (0·65-0·80 mm); width including eyes 2·30 mm (2·20-2·30 mm); interocular distance 1·1 mm; interocellar distance 0·80 mm (0·80-0·90 mm); paraclypei with tips slightly separated from each other, terminating above and subequal to clypeus, basal antennal segments well passing the apex of head, 3rd segments slightly longer than the 2nd antennal segments; length of segments 1, 0·50 mm (0·50-0·55 mm), II, 1·10 mm (0·90-1·1 mm), III, 1·20 mm (1·10-1·20 mm), IV, 1·40 mm, V, mutilated, antennal formula 1<2<3<4; Labium reaching posterior coxae, 1st segment slightly extending beyond bucculae, latter not reaching to the base of head; length of segments 1, 0·80 mm (0·70-0·80 mm), II, 0·95 mm (0·85-0·95 mm), III, 0·60 mm (0·55-0·66 mm), IV, 0·70 mm (0·65-0·70 mm), labial formula 3<4<1<2.

Thorax: Pronotum 2·5x wider than long, length 1·70 mm (1·60-1·80 mm), width 4·30 mm (3·70-4·30 mm); scutellar length about 1¾ x the length of pronotum, scutellar length 3·10 mm, width 2·70 mm (2·65-2·70 mm); metathoracic scent gland ostioles small elliptical, without peritreme and with ill-defined evaporatoria; distance from base of scutellum to apex of clavus 2·15 mm; apex of scutellum to apex of clavus 0·95 mm; apex of scutellum to apex of abdomen (including membrane) 3·10 mm (2·6-3·10 mm).

Abdomen: Anterior margin of 7th abdominal sternum acute in male and medially convex in female, posterior margin medially broadly concave in male and medially bilobed in female, connexiva slightly exposed at repose. Total length ♂ 7·60 mm, ♀ 9·40 mm (9·05-9·40 mm).

Male genitalia: Pygophore (figs. 2-4) nearly 2x wider than long, ventro-posterior margin medially concave with a pair of quadrate processes consisting of a group of hairs at their apices on either inner side adjacent to median concavity; proctiger sclerotized; parameres (figs. 5 and 6) with comparatively short straight stem and elongated tapering curved blade and spine-like inner process at junction of stem and balde; inflated aedeagus (figs. 7 and 8) with a more or less cuboidal theca, broader posteriorly than anteriorly and with minute lateral thecal appendages, conjunctiva along with vesica enclosed in a cup-shaped structure with a hexagonal ventral surface and more or less trapezoidal dorsal surface, dorsal membranous conjunctival appendage taperingly bilobed and semisclerotized apically, ventral membranous conjunctival appendage bilobed and shorter than dorsal membranous conjunctival appendage, penial lobes fused, enclosing a slightly longer vesica.

Female genitalia: (figs. 9 and 10) Posterior margin of triangulin slightly convex; exposed part of 1st gonocoxae 3x broader than long; 9th paratergites with apices truncate with apical angles distinctly touching the posterior margin of 8th paratergites; spermatheca (fig. 10) with spermathecal median dilation divided into a posterior large and anterior small pouch by a constriction, spermatheca with distal duct slightly dilated, bulb without processes.

Material examined: Holotype, Australia, "*Strachia persignata* (Walker)" "57-130" "96" in British Museum (Natural History) London; 1 ♂, 2 ♀ Australia: Queensland, Rockhampton; 1 ♂ Australia: Brisbane, Queensland Mus. R. Hamlin Harris 1914-202; "64"; 1 ♂ Australia: Goodna, 10-11-24, R. Backer "163" "Australia, British Museum, 1926-241" "Australia: Peak Downs", Distant Coll. 1911-"383"; 2 ♂, 2 ♀ Australia, in B.M.(N.H.); 1 ♂, 2 ♀, Australia, Queensland: Bundaberg, Gayndah, Rockhampton, A.M. Lea det.A.Musgrave in South Australian Museum, Adelaide: Australia.

Genus KNIGHTIELLA New Genus

Body predominantly green and less brilliantly patterned than other genera of Strachiini.

Head: Eyes sessile; basal antennal segments uniformly slender, straight, distinctly surpassing apex of head; labium reaching to 4th abdominal segment.

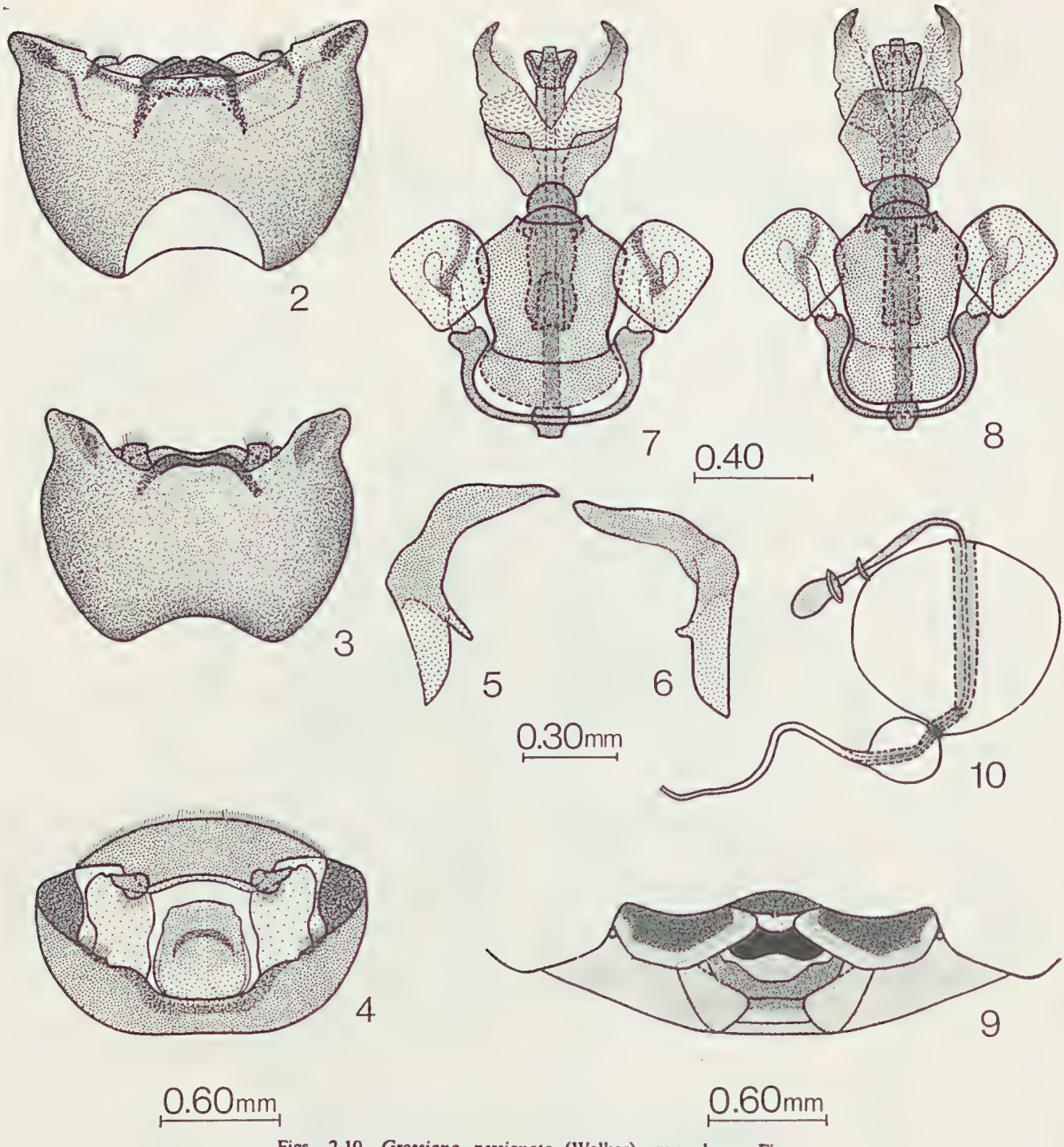
Thorax: Metathoracic scent gland ostioles with elongated well developed peritreme and well defined evaporatoria.

Abdomen: Strigose vittae present on 2nd, 3rd and 4th abdominal segments.

Male genitalia: Pygophore without distinct latero-posterior lobes; parameres F-shaped; inflated aedeagus with vesica distinctly longer than penial lobes and dorsal membranous conjunctival appendage.

Female genitalia: Female terminalia with triangulin visible in between 1st gonocoxae, large, rectangular-shaped and reaching to middle of inner margins of 1st gonocoxae; spermatheca with bulb having one long and one short processes.

Comparative note: Knightiella is isolated in the entire tribe Strachiini in the characters of predominantly green and less patterned body, uniformly slender basal antennal segments passing distinctly beyond apex of head, and in the characters of metathoracic scent gland ostioles and male and female genitalia noted under systematic positions.



Figs. 2-10—*Grossiana persignata* (Walker), pygophore: Fig. 2—Dorsal view; Fig. 3—Ventral view; Fig. 4—Horizontal view, paramere; Fig. 5—Dorsal view; Fig. 6—Ventral view, aedeagus; Fig. 7—Dorsal view; Fig. 8—Ventral view; Fig. 9—Female terminalia, ventral view; Fig. 10—Spermatheca, ventral view.

The genus *Knightiella* is named in the honour of Dr. W. J. Knight who is in charge of the Hemiptera Section, British Museum (Natural History) London to recognise his work on Hemiptera.

Type-species: Stenozygum flavifrons Distant, 1914.

Knightiella flavifrons (Dist.)

(Figs. 11-21)

Stenozygum flavifrons Distant, 1914, p. 375.

Coloration: Body green with prominent yellow and light green markings, uniformly punctured except head (fig. 11); ventrally green with head, thoracic sternum, posterior coxae, lateral margins of propleuron, small outer portion of mesopleuron, posterior margin of metapleuron yellow, 4th and basal portion of 5th labial segments brown, and apex of labium black, portion around ostioles and peritreme white, lateral and a little outer posterior margin of each abdominal segment and broad median protion of 2nd-6th abdominal segments yellow.

Head: Anteocular portion equal to the posterior portion of head including eyes, length of anteocular portion 0·65 mm (0·65-0·70 mm), length of posterior

portion of head including eyes 0·65 mm (0·65-0·70 mm); width including eyes 1·75 mm (1·75-1·85 mm); interocular distance 0·95 mm (0·95-1·05 mm), interocellar distance 0·60 mm (0·60-0·65 mm); paraclypei with tips separated and subequal to the clypeus; basal antennal segments uniformly slender, straight, distinctly passing the apex of head, 3rd segments slightly longer than 1½ x the length of 2nd antennal segments; length of segments I, 0·45 mm (0·45-0·50 mm), II, 0·60 mm, III, 1·00 mm, IV, & V. mutilited, labium reaching to 4th abdominal segment, 1st segment distinctly extending beyond bucculae, latter not reaching to the base of head; length of segments I, 0·95 mm, II, 1·10 mm, III, 0·60 mm, IV, 0·65 mm, labial formula 3<4<1<2.

Thorax: Pronotum slightly more than 2·5 x wider than long, length 1·30 mm (1·30-1·40 mm), width 3·40 mm (3·40-3·80 mm); scutellar length about 1¾ x the length of pronotum, scutellar length 2·35 mm (2·35-2·55 mm), width 2·20 mm (2·20-2·40 mm); metathoracic scent gland ostioles (fig. 12) with

Fig. 11—*Knightiella flavifrons* (Dist.) male dorsal view.

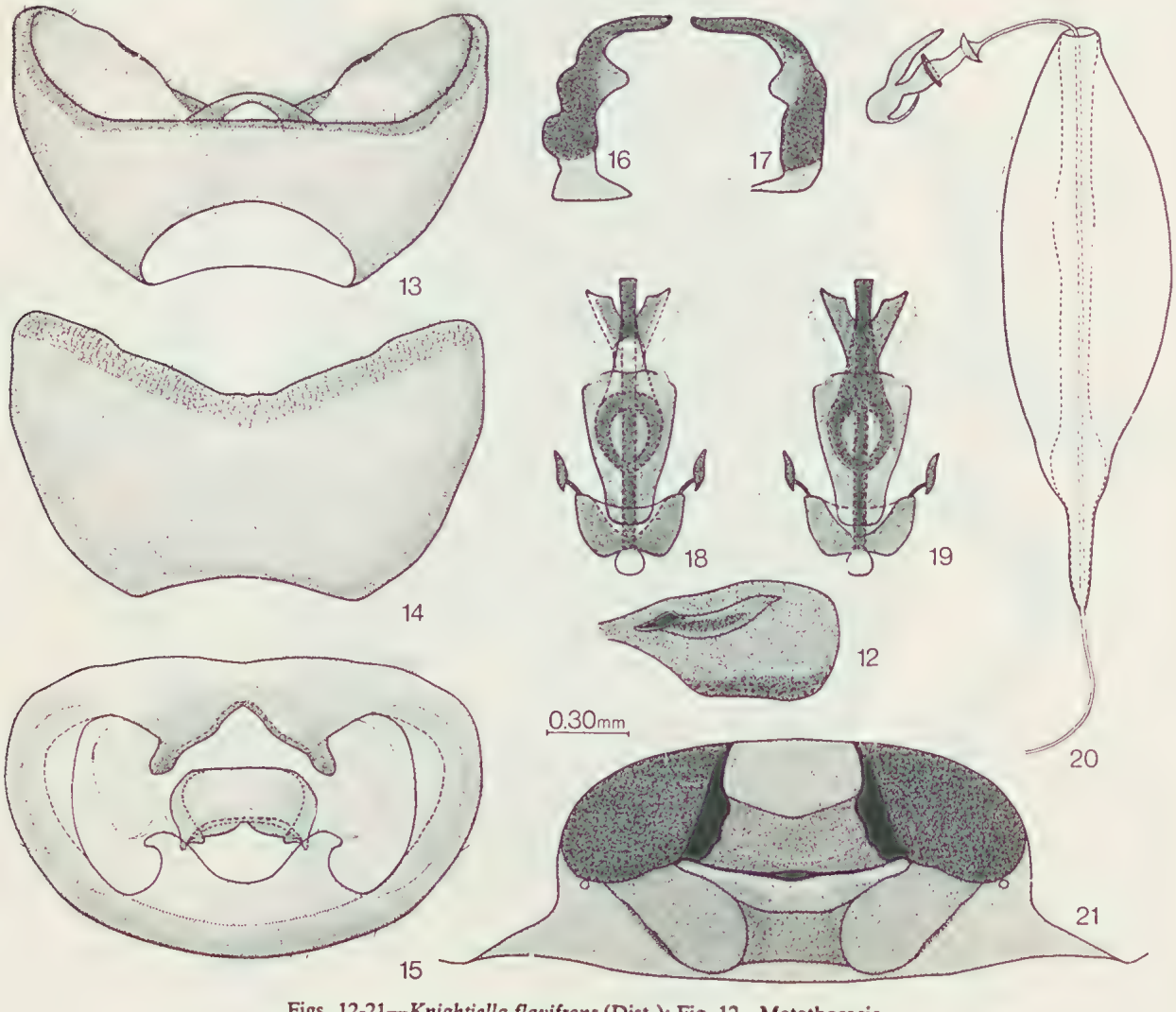
elongated crescent-shaped peritreme and well defined evaporatoria; distance base of scutellum to apex of clavus 1·60 mm (1·60-1·80 mm); apex of scutellum to apex of clavus 0·75 mm; apex of scutellum to apex of abdomen (including membrane) 2·05 mm (2·05-2·20 mm).

Abdomen: Anterior margin of 7th abdominal sternum medially broadly and smoothly convex and posterior margin medially broadly and smoothly concave in male and female; connexiva not exposed. Total length ♂ 7·0 mm, ♀ 7·55 mm.

Male genitalia: Pygophore (figs. 13-15) nearly 3x broader than long in middle, ventroposterior margin medially broadly concave with a pair of elongated lobe-like appendages on either side of median concavity (visible in posterior view only); proctiger sclerotized posteriorly and laterally while remaining portion thin and membranous; parameres (figs. 16 and 17) with a short foot-like stem and a long irregularly-shaped blade with outer three bulges, large inner tooth and distal curved part rounded apically, inner tooth and distal part of parameres imparting a more or less F-shaped appearance to this structure; inflated aedeagus (figs. 18 and 19) with elongated theca tapering posteriorly without distinct lateral thecal appendages, dorsal membranous, conjunctival appendage bilobed, equal to penial lobes, latter fused anteriorly and terminating into truncate apices.

Female genitalia: (figs. 20-21) Posterior margin of triangulin with an obtuse angle in middle; exposed part of 1st gonocoxae slightly broader than long; 9th paratergites with apices rounded, with apical angles not touching the posterior margin of 8th paratergites; spermatheca (fig. 21) with elongated median dilation, without any constriction and with uniform distal duct and two processes on the bulb, one thicker and larger as compared to other.

Material examined: 2 ♂, 1♀ New Caledonia: Ba Bay. 5-VII-19174, P. D. Montague 1918-87 "New Caledonia Exped". *Stenozygum flavifrons* Dist. "C. H. Lyal det. 1977 British Museum (Natural History) London.



Figs. 12-21—*Knightiella flavifrons* (Dist.): Fig. 12—Metathoracic scent gland ostioles, pygophore; Fig. 13—Dorsal view; Fig. 14—Ventral view; Fig. 15—Horizontal view, paramere; Fig. 16—Dorsal view; Fig. 17—Ventral view; aedeagus; Fig. 18—Dorsal view; Fig. 19—Ventral view; Fig. 20—Female terminalia, ventral view; Fig. 21—Spermatheca, ventral view.

SYSTEMATIC POSITIONS

The Genus *Knightiella* is not only very different from all the species of the genus *Stenozygum* but is completely isolated in the entire tribe Strachiini Stål, 1876 (*Strachia* group Gross, 1976) on the basis of metathoracic scent gland ostioles with well developed peritreme and completely defined evaporatoria, aedeagus with vesica distinctly longer than penial lobes, parameres F-shaped and spermathecal bulb with processes. It has strigose vittae on II, III and IV abdominal segments laterally similar to those in the members of Mecideini Distant, 1902 and of *Diemenia* group Gross, 1976. The members of the former group are generally elongated and slender having shorter peritreme in the metathoracic scent gland ostioles and have lobe-like short and rounder blade without inner lobe in parameres, aedeagus with elongated and conical lateral conjunctival lobes and the spermatheca is without processes on the bulb. In the latter group the paraclypei generally surpass the clypeus and may be reflexed laterally and often produced into small lobes or processes in front of the eyes, the aedeagus has prominent bilobed conjunctiva with or without additional median and ventral lobes and the vesica is short and robust (Sailer 1952, Abbasi 1974, Gross 1976).

On the other hand F-shaped parameres are found in the species of Carpocorini Stål, 1876 (*Carpocoris* group Gross, 1976) including the species of *Agonoscelis* Spinola, 1837 for which Stål (1876) formed his division Agonoscelaria and this was also followed by Atkinson (1888). Similarly F-shaped parameres are found in many species of Halyini Stål, 1872 (*Halys* group Gross, 1976) as reported by Ahmad and Abbasi (1974), Abbasi and Ahmad (1975), Gross (1976) and Ahmad and Afzal (in manuscript). Some of the species of *Diemenia* group also have rather blade-shaped parameres which could look vaguely F-shaped (Gross, personal communication). But in none of these groups a combination of characters as listed in the generic description are found. Either it should have its own group within the subfamily Pentatominae or its position remain unascertained until a world wide revision of the subfamily is completed.

On the contrary the genus *Grossiana* certainly belongs to the tribe Strachiini in the characters of metathoracic scent gland ostioles without peritreme and with ill-defined evaporatoria, brilliantly coloured body, somewhat stylate eyes, simple sickle-shaped parameres in the male and bilobed spermathecal median dilation without processes on the bulk of the females. However *Grossiana* differs remarkably from all the species of the genus *Stenozygum* in the characters of the long, uniformly swollen and slightly inwardly curved basal antennal segment surpassing apex of head (in *S. laetibile* (Walker) the basal antennal segment distinctly surpasses the apex of head but the second is distinctly shorter than the third) and the second antennal segment subequal to third. The latter is also found in the species of *Strachia* but the prominent laterally bilobed pronotum, the simple hook-like parameres, and the medially deeply concave posterior margin of the seventh female abdominal sternum in all the species of *Strachia* (Ahmad & Kamaluddin 1978) clearly separate the two genera.

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SOME REMARKS ON THE BREEDING DISTRIBUTION AND TAXONOMY OF THE PRIONS (PROCELLARIIDAE: *PACHYPTILA*)

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ABSTRACT

COX, J. B. 1979. Some remarks on the breeding distribution and taxonomy of the Prions (Procellariidae: *Pachyptila*). *Rec.S.Aust. Mus.* 18(4): 91-121.

The breeding distributions of prions are reviewed and the characters used to differentiate *Pachyptila vittata, P. salvini, P. desolata, P. belcheri, P. turtur* and *P. crassirostris* are critically assessed. Feeding habits and the concept that differing breeding times isolate these prions genetically are also discussed. Evaluation of the evidence indicates that their previous classification into three genera or subgenera is invalid because only two groups are clearly separable by morphological characteristics: the Fairy Prions (*turtur* and *crassirostris*) and the Whale-Birds (*belcheri, desolata, salvini* and *vittata*). The former are considered to be one polytypic species and the whale-birds to be one monotypic and one polytypic species.

Characters described as differentiating *turtur* and *crassirostris* intergrade through many island populations north-south and west-east. However, the sharp boundary between each form in the Chatham Is. allows their recognition as subspecies, although elsewhere delimitations are arbitrary. The characteristics of whale-birds also intergrade, but in their case two species can be recognised. *P. belcheri* is here treated as specifically distinct from the *desolata-salvini-vittata* complex, although they have a zone of overlap and hybridization in the subantarctic Indian Ocean. Southern *desolata* and northern *vittata* are in all probability conspecific and evidently *salvini* is an intermediate form of hybrid origin. In two southern oceanic regions (South Atlantic and New Zealand) there are no intermediates between *desolata* and *vittata* and both are clearly distinguishable; but in the southern Indian Ocean region their differences are less pronounced and intergrade through *salvini* populations.

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I. INTRODUCTION

The small southern oceanic petrels known as prions or whale-birds were at different times classified in several genera, a varying number of species and many subspecies by Mathews (1912, 1932, 1937, 1938). Murphy (1936) disagreed with Mathews' changeable concepts and believed there were only four species in the single genus *Pachyptila*. His elucidation of the group was welcomed by Fleming (1939) who defined a fifth species. In a later systematic review Falla (1940) recognised five polytypic and one monotypic species of three sub genera, and Fleming (1941) hypothesized their phylogeny. Some of these species had minor differences in plumage coloration, but all six were distinguishable only by the size, shape and structure of their bills, occasionally in conjunction with relative wing dimensions. In this respect systematists have emphasised the distinctiveness of prion bills. Murphy (1936) wrote that the bill of each species "stands out clearly as a distinct entity, without exhibiting a degree of variation which might be interpreted as intergradation." Fleming (1941) considered that "the bill characters by themselves are diagnostic."

Contrary to these views there is increasing awareness that the bill characters of each species vary greatly. Clancy (1965) and Watson (1975) listed *salvini* and *vittata* as conspecific. Furthermore, beach-washed specimens of unknown origin are frequently not identifiable (Cox 1976). Nevertheless, most authors still follow Falla's (1940) classification and difficulties in identification have been explained in various ways. Fullagar (1972) wrote: 'Since identification depends so much on the form of the bill, not only its size, but also an appreciation of its shape, many of the subtle characteristics of each species can be recognised only with experience.' Serventy *et al.* (1971) noted that some immatures have smaller bills and may not be recognisable, and Kinsky and Harper (1968) showed that through shrinkage the bill-width of dried specimens may be less than in fresh or live specimens. However, under the current classification of species these points do not appear realistic

when, as is often the case, two otherwise indistinguishable specimens are allocated to different species simply because their bill-widths differ by one or two millimetres.

II. METHODS

In an attempt to resolve the problems of identification, specimens of adults from most known breeding places were obtained on loan to the South Australian Museum from eight other museum collections. Specimens collected at sea were also borrowed, and use was made of numerous beach-washed birds collected by myself, and from Australian museum collections.

Falla (1940) wrote "the older preoccupation with bill *measurements* for specific diagnosis is misleading" and the "importance of emphasis on certain bill *characters* was first clearly stressed by Mathews". However, bill characters can be adequately specified only by illustration and most authors have shown only one supposedly typical bill of each species (Murphy 1936; Fleming 1941; Slater 1970; Serventy *et al.* 1971; Fullagar 1972; Macdonald 1973; Watson 1975). This aspect has obscured the existence of great variation in the bills of the species recognised. For these reasons, a range of prion bills are here illustrated. The drawings were all made at twice actual size on graph paper of two-millimetre squares direct from specimens, traced onto cartridge paper and reduced to actual size for publication. The museum registration numbers of each specimen are given, and each drawing is also consecutively numbered and prefixed A (Fairy Prions) or B (Whale-Birds) for cross references.

Measurements were all taken from dry skins in accordance with methods described by Disney *et al.* (1974) but, because many authors have emphasised that the bill is the major identification feature of prions, the methods of measuring bills are detailed: culmen—from the juncture of the forehead feathers and nasal tubes taken as a chord to the bill tip; bill width—taken at the widest point of the bill, usually but not always at the base; bill depth—a vertical line from the point immediately in front of the nostrils to the underside of the lower mandible on a properly closed bill. McEvey (1957) showed that measurements taken from the same specimens by different persons sometimes vary; therefore, there may be small differences between the dimensions I give and those given by other writers. All dimensions cited are in millimetres.

Registration numbers of specimens are abbreviated: AMNH—American Museum of Natural History, New York; AMS—Australian Museum, Sydney; BMNH—British Museum (Natural History), Tring; CMC—Canterbury Museum, Christchurch; CSIRO—C.S.I.R.O. Division of Wildlife Research, Canberra; DMW—Dominion (now National) Museum, Wellington; MNHN—Muséum National d'Histoire Naturelle, Paris; NMV—National Museum of Victoria, Melbourne; SAFM—South Africa Museum, Capetown; SAM—South Australian Museum, Adelaide.

Various Geographical regions and zones are considered. Murphy (1936) and Serventy *et al.* (1971) have described the surface water zones of the Southern Ocean; the Antarctic and Subtropical Convergences are shown in Figure 1. Definitions of the Antarctic and Subantarctic Zones follow Roberts (1964), and the Subtropical Zone is considered here to be the seas north of the Subtropical Convergence. Different sectors of the Southern Ocean are also discussed: the southern Atlantic region (from southern South American and Antarctic Peninsulas and outlying islands, east to South Africa, approximately 18°E); the southern Indian Ocean region (from 18°E to the Western Australian coastline, approximately 115°E); and the Australian-New Zealand region (from 115°E to 165°W). Prions breed at many localities in each of these sectors, but are not known to breed in the southern Pacific Ocean sector between 165°W and 75°W.

III. OBSERVATIONS

(a) BREEDING DISTRIBUTION

Prions occur over the antarctic, subantarctic and neighbouring subtropical seas, and breed on oceanic and offshore islands and the mainlands of Antarctica and South I., N.Z.. The breeding grounds of each recognised species have been frequently listed incorrectly and require clarification. They are shown in Figure 1 and listed below, but some remain indefinite.

Falla (1940) did not clearly define the breeding distribution of *P. turtur fallai* Oliver, 1930. With the exception of this subspecies, all subspecies he recognised are listed, but with later evidence and amendments included.

P. turtur (Kuhl, 1820): Islands of Bass Strait, off Tasmania (Wood Jones 1937; Condon 1975), and off New Zealand from the Poor Knights Is. south to Cook and Foveaux Straits (Falla *et al.* 1966, Condon 1975); Snares Is. (see below); Big and Little Mangere Is. of the Chatham Group (Fleming 1939, Falla 1940); Marion I. (van Zinderen Bakker 1971) and Beauchene I., Falkland Group (Strange 1968). Also, probably on Île de l'Est of Archipel Crozet (Despin *et al.* 1972), possibly Antipodes Is. (see below), and two specimens were collected on Macquarie I. (Keith and Hines 1958).

I agree with Condon (1975) who wrote that no subspecies "can be recognised at this time." Falla

Fig 1.—Breeding distribution of prions.

(1940) listed the breeding distribution of *fallai* as: "*Breeding:* Stewart Island, Akaroa, Chatham Islands, ? Bass Straits, ? South Indian Ocean or West Australia." He also listed Bass Strait, Chatham Is. and ? Stewart I. in the breeding distribution of nominate *turtur*. Falla *et al.* (1966) said Antipodes Is. *turtur* are a small subantarctic race (*P. turtur subantarctica* Oliver, 1955), although, when naming the subspecies, Oliver (1955) suggested they are a larger form because he wrote that a specimen "thus resembles *P. crassirostris* more than *P.t.turtur.*".

Snares Is.: Falla (1940) said 'Oliver's suggestion (1930: 115) that the stout-billed form occurs at the Snares is not supported by a specimen, in the Otago Museum, which has the bill form of typical *P.t.turtur.*' Oliver later (1955) listed this specimen as *P.t.turtur*. Fleming (1948) wrote that on the main Snares Island "Fairy Prions (*Pachytila turtur)* nested deep in rock crevices among boulders piled along the shores." Warham (1967) also reported *turtur* "nesting solely in rock crevices and talus debris" on the main island, but after a fourteen-month stay on this island Horning Jr. and Horning (1974) only

reported "Prions, probably both Fairy (*Pachyptila turtur*) and Broad-billed, were seen flying near and over the main island during most months," without mention of breeding. Fleming and Baker (1973), reporting on birds of the Western Chain of islands in the Snares Group, wrote "A new record from the Snares is the Fulmar Prion (*Pachyptila crassirostris*) which we found perching on ledges and nesting in crevices". Sagar (1977a) said the "Fulmar Prion" was found on the Western Chain and that "On Rima nests were found in the NW and NE areas of the islet. Here large rocks formed a jumble over the solid rock foundations. Nests were deep under these rocks". Surprisingly, Edgar (1977) wrote that Sagar had found the "Fairy Prion" on "Snares Islands" and Sagar's report (1977b) of the birds found during his expedition to the Snares included no mention of Fairy or Fulmar Prions. J. Warham (pers. comm. 1976) said that he is not aware of any specimens of *crassirostris* taken from the Western Chain of the Snares. Therefore it is difficult to assess whether typical *crassirostris* do in fact breed there.

It is known that prions of the Western Chain and the main Snares Island have similar nesting habitats and preferences, and that they probably breed at the same time. Sagar (1977a) reported that Fulmar Prions on the Western Chain had eggs on 21 November, and Warham (1967) reported that Fairy Prions had chicks on the main island in January-February (see below —"Differences in Breeding Times"). Therefore the only differences between the birds must be morphological. Photographs of nesting Fairy Prions from Motunau I. and from Snares I. published by Serventy *et al.* (1971: Figs 62 and 139) show that birds from both localities have very similar bills. Furthermore, another photograph of two Fulmar Prions at the Western Chain of the Snares, published by Fleming and Baker (1973), depicts a bird with a bill that is certainly too slender for a typical *crassirostris*, albiet rather unclear. Because Motunau I. prions vary, and some are not separable from *crassirostris*, while others are indistinguishable from *turtur* (see below—"Comparative Morphology"), the evidence strongly suggests that the Snares Group also contains one variable form of Fairy Prion. It is further interesting that there are no reports of two different forms breeding during single expeditions to the Snares, or to the Antipodes Is. where two forms have also been reported to breed (see below); this aspect suggests that the prions have been indiscriminately identified as either *turtur* or *crassirostris*.

P. crassirostris eatoni (Mathews, 1912): Heard I. (Falla 1937; Downes *et al.* 1959) and Auckland Is. (Falla *et al.* 1966). Also, possibly on the Antipodes Is. (see below).

Although Condon (1975) listed îles Kerguelen as a breeding ground, only one bird (the type of *eatoni*) is known from this locality (Derenne *et al.* 1974) and there is no evidence of breeding.

P.c.crassirostris (Mathews, 1912): Bounty Is. (Falla 1940).

P. crassirostris pyramidalis Fleming, 1939: Pyramid Rock, possibly Forty Fours islets and probably The Sisters islets of the Chatham Group (Fleming 1939; Falla 1940; Dawson 1955).

Dawson (1955) found that burrows on the eastern Sister islet contained 'two almost fully-fledged young of the Chatham fulmar prion'. Whether these birds were *crassirostris* or *turtur* is open to doubt. They were found in 'burrows' at the end of January, which indicates, if one followed Fleming's assertions (1941) that *turtur* breeds earlier than *crassirostris*, that they were *turtur* which came from eggs laid in mid-October (see below—'Differences in Breeding Times'). Also, *crassirostris*, at all other localities where it is known to breed, nests in rock crevices, under boulders, or in similar sites, and is not known to nest in 'burrows'. However, the identification of many prions breeding in the Chatham group is questionable, because A. Wright stated (pers. comm. 1975) that during extensive work on these islands he found many prions that were not distinguishable as *turtur* or *crassirostris*.

Antipodes Is.: Whether *turtur* or *crassirostris* or both breed at the Antipodes Is. is unconfirmed. Many writers have stated that one or both forms breed on these islands, but their source of information is obscure. Both are little known from this locality and Dr J. Warham (pers. comm. 1976) stated that he knows of no specimens actually taken on land. Dr F. C. Kinsky (pers comm. 1976) agreed that none was known to have been taken on land, but suggested that *turtur* does breed there, because two specimens, taken on board ship anchored close to the rocky shoreline in 1950, were in breeding condition and had 'naked brood patches.'

Although Oliver (1955) said of Bounty Is. birds *(crassirostris)* that 'this subspecies was found breeding at Antipodes Island in 1902,' it seems that his statement stems from two specimens that are in the Canterbury Museum. Waite (1909) mentioned these specimens, and Falla (1940) gave their registration numbers as 1200.1. Two *crassirostris* labelled 'Antipodes Is.' are in the Canterbury Museum. Both are dated 1949, but this date probably is when their registration numbers were changed to CMC AV1208 and CMC AV1247, because they appear to be very old and were once mounted; doubtless, they are the same two specimens mentioned by Waite and Falla. Interestingly, Waite also said that a specimen of *'Prion*

desolatus' was obtained at the Antipodes Is. in February 1907; but this specimen was probably either *turtur* or *crassirostris* (its present location is not known) because Waite said 'Captain Bollens tells me that this *Prion* breeds in crevices in rocks at the Bounty Islands' (which implies it was not found breeding at the Antipodes Is.) and he listed the *desolata* of Auckland Is. as *'Prion banksii'*.

Oliver (1955) listed specimens of *turtur* taken at the Antipodes Is. on 31 July 1924 and in November 1950. It is unlikely that the July specimen was breeding, for that month is outside the normal breeding season, and the 1950 birds are those which were taken aboard ship. Of two specimens examined, one (DMW 17222) is labelled 'off Antipodes Is.' and dated 21 November 1972, and the other (DMW DM5615) is a bird listed by Oliver, labelled 'Antipodes Is.' and dated 6 November 1950—one of the birds taken aboard ship.

From these data all one can say is that both forms have been collected either on or near the Antipodes Is. There is therefore a possibility they do breed at this locality, but Warham added *(loc. cit.)* that a recent thorough search of the islands during the breeding season failed to find any prions. Summarizing, it seems that all reports of these prions at the Antipodes Is. stem from two *crassirostris* taken, not necessarily on land, in 1902, a doubtfully identified specimen taken in 1907, a single *turtur* taken outside the breeding season in 1924, and a few other *turtur* taken at later dates over the nearby sea. Consequently there are no grounds to suggest both forms breed sympatrically at the Antipodes Is.

P. belcheri (Mathews, 1912): Falkland Is. (Cawkell and Hamilton 1961), Île de l'Est of Archipel Crozet (Despin *et al.* 1972) and Îles Kerguelen (Falla 1937, Derenne *et al.* 1974). Also, possibly on Staten I. and offshore islets of Tierra del Fuego (Harper 1972), and the remains of birds were found in the nests of the Great Skua *Stercorarius skua* on South Georgia (Watson 1975).

Serventy *et al.* (1971) and Condon (1975) listed Bouvetøya as a breeding ground of *belcheri*, but Fleming (1941) and Tickell (1962) suggested that only *desolata* breeds there. Holgersen (1960) did not list prions in his review of the birds of Bouvetøya, and later papers by Solyanik (1964) and Holdgate *et al.* (1968) are probably significant in that they do not mention prions breeding or seen on Bouvetøya. Most *desolata* breed on islands in the Antarctic Zone, and Murphy (1936) said, without evidence but merely because Bouvetøya is in the Antarctic Zone, that *desolata* presumably breed on Bouvetøya. Later confusion has doubtless resulted from such conjecture.

P. d. desolata (Gmelin, 1789): Îles Kerguelen (Tickell 1962).

P. desolata banksi Smith, 1840: South Georgia, S. Orkney Is. and Heard I. (Tickell 1962).

P. desolata alter (Mathews, 1912): Auckland Is. and Macquarie I. (Tickell, 1962).

P.desolata subsp.: Île de l'Est of Archipel Crozet (Despin *et al.* 1972); S.Sandwich Is., S.Shetland Is., Scott I. (Harper 1972; Watson 1975) and Cape Denison of Antarctica (Falla 1937).

Falla (1937) listed three specimens collected at Cape Denison in 1913, and wrote that five birds were seen and three eggs found. In January 1931, he sighted one bird flying towards land in the evening. There are no further reports of *desolata* at this locality. Watson (1975) wrote that the Cape Denison population is "possibly extirpated."

P.s.salvini (Mathews, 1912): Marion and Prince Edward Is. (van Zinderen Bakker 1971).

P.salvini crozeti (Mathews, 1932): Archipel Crozet (Despin *et al.* 1972).

P.vittata macgillivrayi (Mathews 1912): Île Saint-Paul and Île Amsterdam (Mathews 1912; Falla 1940). According to Watson (1975) the last population is "probably extirpated" and subject to offshore stacks being searched, only a few birds may still breed on Île Saint-Paul.

P.v.vittata (Forster, 1777): The Tristan da Cunha Group and Gough I. (Murphy 1936, Swales 1965); the mainland coasts of Foveaux Strait and south western fiords of South I., New Zealand, islets off Stewart I., Snares Is. and the Chatham Group (Fleming 1939, Richdale 1965; Falla *et al.* 1966). Also, two *vittata* were collected in the Falkland Is. (Cawkell and Hamilton 1961).

Condon (1975) followed Clancy (1965) in listing South Georgia as a breeding ground of *vittata*. However, Murphy (1936) considered that *desolata* of South Georgia had been confused with *vittata* and that this mistake in identification was subsequently carried on by others through quotation. But both Murphy and Clancy listed *vittata* as breeding on the Auckland Is. This locality was not listed by Falla (1940), Falla *et al.* (1966), Serventy *et al.* (1971), Condon (1975) and Watson (1975). According to Tickell (1962) *desolata* breeds on South Georgia and the Auckland Is.

(b) COMPARATIVE MORPHOLOGY

All prions have white underparts, a pale superciliary, blue-grey ear coverts and upperparts with a dark "M" across the wings and rump, a black terminal tail patch, bright blue feet with paler webs,

and blue-grey or dark grey bills. Their bills are diverse in shape and have a row of comb-like lamellae inside the cutting edges of the upper mandibles. These lamellae are well-developed in broader-billed forms but are often present only as rudimentary ridges in narrower-billed forms.

Two groups of prions are readily recognisable: the fairy prions (*turtur* and *crassirostris*) and the whale-birds (*belcheri, desolata, salvini* and *vittata*). The usage of these vernaculars follows Murphy (1936).

In many cases prions of each group are separable by bill characteristics only. Compared with whale-birds, most fairy prions have stouter (shorter and deeper) bills with a proportionately larger and more bulbous dertrum. The exceptions are some *turtur* that have bills closely resembling those of some *belcheri* (Fig. 2: *cf* A1, A2, B1), or, in external appearances only, even those of some *desolata*. Birds of both groups are more easily recognisable by marked differences in the amount of black on their tails and slightly different head plumage colorations.

PLUMAGE PATTERNS

There are three plumage patterns evident in the prions: (1) fairy prions have a large area of black on the tail and a fairly uniform pale head and facial pattern; (2) whale-birds have a small area of black

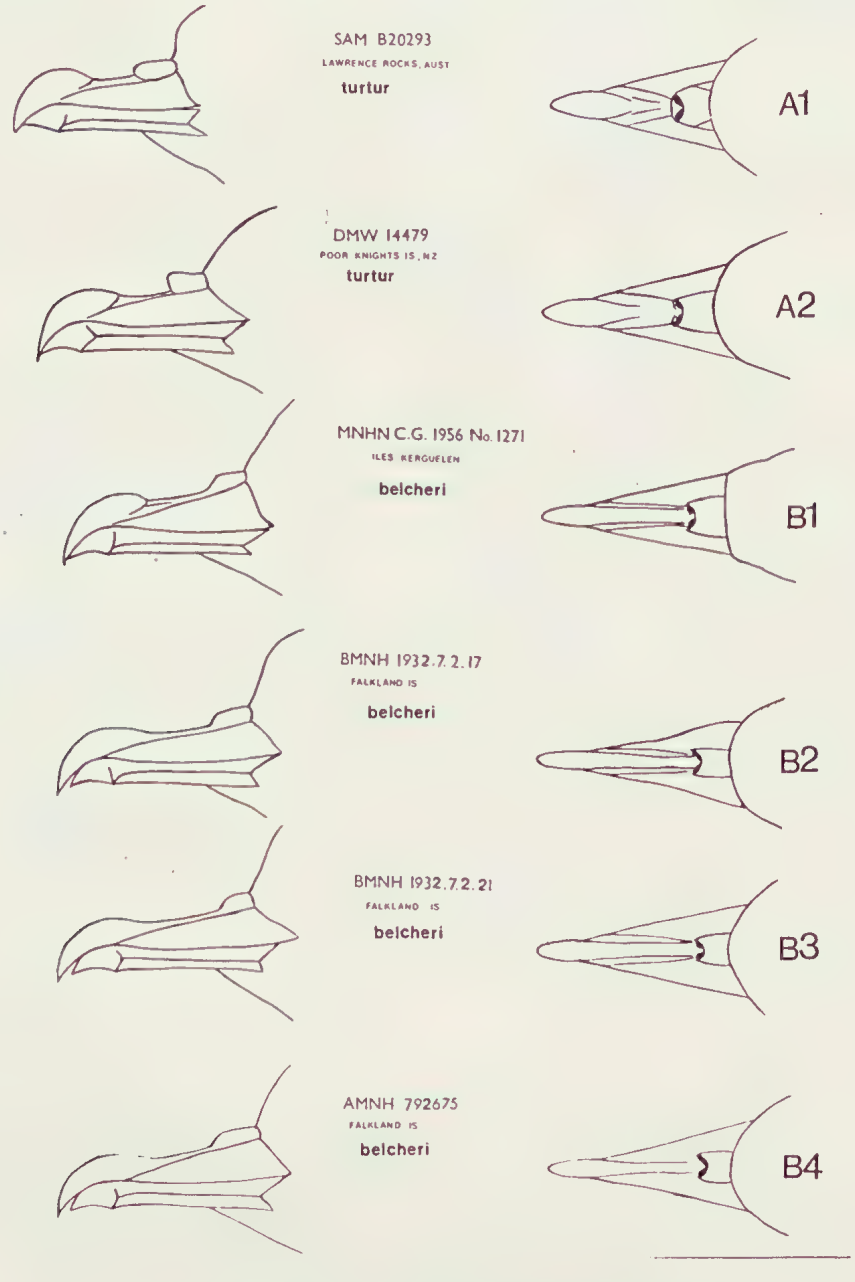

Fig. 2.—Bills of some fairy prions and whale-birds compared to show that some birds of each prion group have similar bills. In this and subsequent illustrations of prion bills, the drawings were all made direct from specimens. The bills of some specimens were not set properly in preparation or, since they have dried, shrinkage of the bill plates has caused distortion. These aspects were copied to achieve a true representation of the specimens. In life the nasal tubes of prions are soft and, consequently, after death they gain a variety of shapes which are not indicative of distinctions.

on the tail; of the latter *belcheri* has a prominent white superciliary and facial area contrasting with a dark blue-grey crown and ear coverts, and a pale grey back; *desolata, salvini* and *vittata* usually have a darker facial area, back and sides of breast. Examples of these plumage patterns are shown in Figures 3 and 4. These patterns are usually constant, but some *desolata* have plumage indistinguishable from some *belcheri*.

Tail Patterning

SAM B30285 and SAM B30288 (Fig. 3) are beach-washed specimens of *turtur* and *belcheri* respectively, prepared with spread tail feathers to show the differences in uppertail patterning between the two prion groups. Watson (1975) incorrectly showed in illustrations that fairy prions differ from whale-birds by having black extending in a broad band across the outer rectrices. All prions have pale grey outer rectrices.

The black terminal tail patch of fairy prions extends for about half the tail length on the upper surfaces of the inner rectrices. Specimens examined from all populations have the outer rectrices wholly pale grey and the second outer pair have a trace of black on the ends of the inner vanes only. The inner pairs have progressively larger areas of black with that of the central feathers underlying the ends of the uppertail coverts, the extreme tips of which are also sometimes blackish.

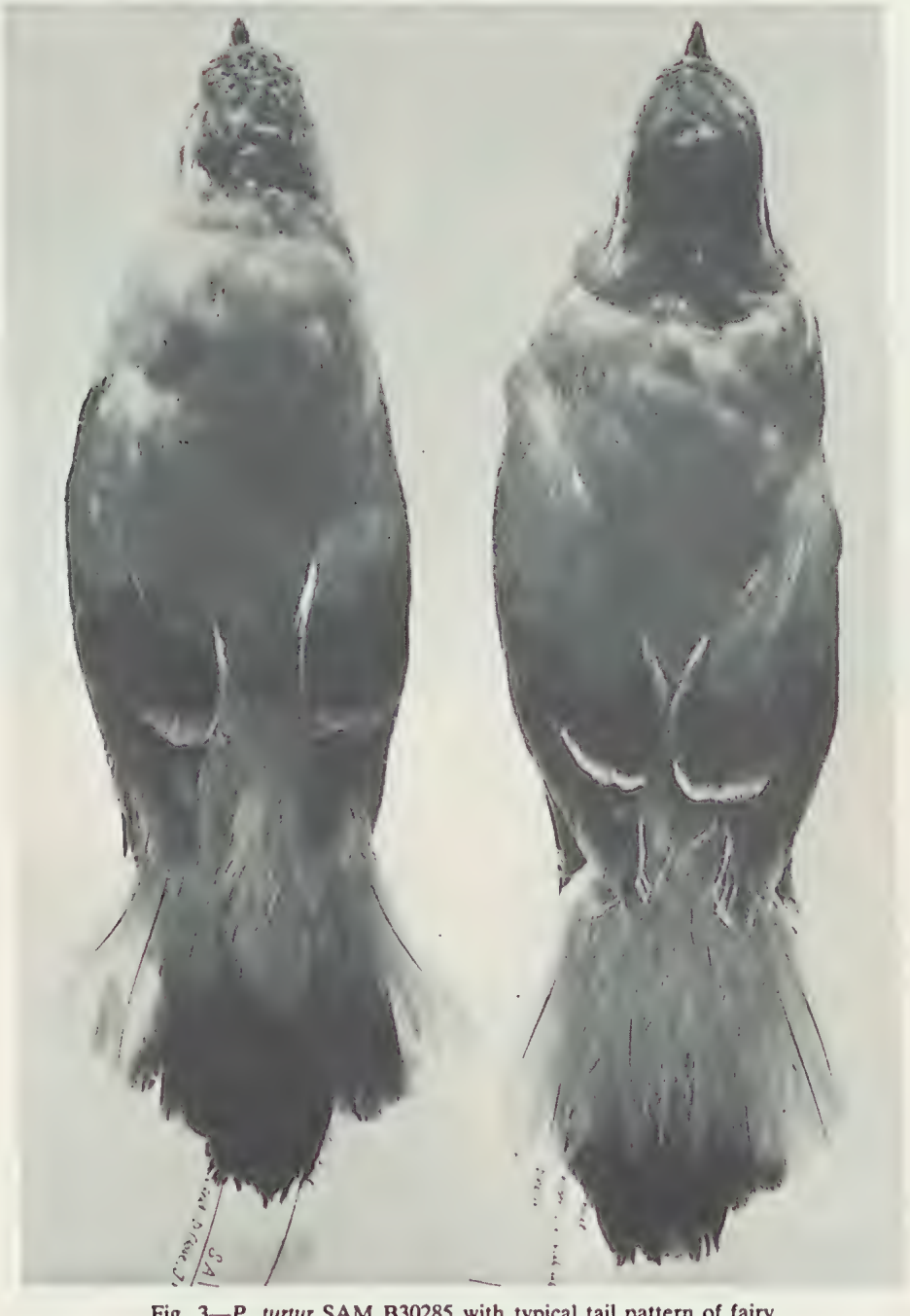

Fig. 3—*P. turtur* SAM B30285 with typical tail pattern of fairy prions (left) and *P. belcheri* SAM B30288 with typical tail pattern of whale-birds (right). Note the grey outer rectrices in each species and that the black of the tail extends to the uppertail coverts.

In whale-birds the terminal tail patch occupies less than a third of the tail length on the upper surfaces of the inner rectrices. The two outer pairs of rectrices are wholly pale grey and the inner rectrices have progressively larger areas of black, with that of the central pair extending to the tips of the uppertail coverts.

Head and Body Coloration

Fairy prions have paler, more uniformly coloured heads than whale-birds, but like *belcheri* have a pale grey back (fig. 4). The fore part of the crown of fairy prions is usually slightly, but distinctly mottled, and the dark coloration of their ear coverts, while variable, is usually not extensive. The sides of their breasts, flanks and undertail coverts are lightly coloured blue-grey, and on some specimens this colour extends over the abdominal feathers; this last feature being particularly noticeable on some Falklands Is. and Pyramid Rock (Chathams Group) specimens.

Fig. 4—Head and back coloration of *P. belcheri* (SAM B30288, left), *P. turtur* (SAM B30285, middle) and *P. vittata* subsp. (SAM B29293, right). Note: these are selected examples to illustrate basic differences; some *vittata* have paler plumage than the specimen shown.

Harper (1972) correctly illustrated *belcheri* as having white lores and a broad superciliary, which, in all specimens I examined, contrasts with a uniform dark blue-grey crown and ear coverts. He also stated that *desolata* differs from *belcheri* by having darker breast markings and "M" pattern across the wings and rump, mottled grey lores and a much smaller pale superciliary.

Specimens of *belcheri* and *desolata* that I examined from populations studied by Harper usually showed the differences he describe; but some *desolata* had intermediate plumage colorations. Tickell (1962) published photographs of *desolata* showing a broad white superciliary, and Îles Kerguelen *desolata* are often indistinguishable from *belcheri* by plumage. For example, Îles Kerguelen *desolata* BMNH 80.11, 18.687a and BMNH 80.11.18.647g and Falkland Island *belcheri* BMNH 1932.7.2.21 and BMNH 1932.7.2.17 were critically examined and could not be differentiated by plumage coloration. Therefore, the two forms are not so clearly identifiable as Harper believed, and extreme caution must be used in separating them by plumage features alone.

Fleming (1941) stated that *salvini* and *vittata* have darker plumages than *desolata*, but Harper and Kinsky (1974) did not differentiate them by plumage coloration. There was little difference between these forms in specimens examined, except for a tendency for larger-billed birds to be darker; but there is much variation. For example, of two *vittata* collected on Île Saint-Paul by the same person, one (MNHN

C.G. 1875 No. 112) has white lores slightly mottled grey and a prominent white superciliary, while the other (MNHN C.G. 1875 No. 115) has almost wholly grey lores and very little white above the eye, making the head appear almost uniformly grey.

The six examples cited above are typical of many specimens examined. Most îles Kerguelen *desolata* are indistinguishable by plumage from *belcheri*, whereas *desolata* from other populations usually are separable. Other whale-birds, from one or different populations, vary in depth of plumage colour like most *desolata*.

THE FAIRY PRION GROUP

Many island populations of these prions have been characterised by bill distinctions. Consequently two species are generally recognised: northern slender-billed *turtur* and southern stout-billed *crassirostris*.

Following descriptions of Falla (1937), Fleming (1941) and Fullagar (1972) I previously stated (Cox 1976) that *crassirostris* is distinguishable from *turtur* by having a dertrum lacking an angular ridge, bulbous latericorns and a bill appearing bowed outwardly when viewed from above. Subsequent examination of specimens from most known breeding localities of both forms showed that this definition was incorrect. Individuals of each form can have dertra the same size and shape, and bowed or straight bill outlines when viewed dorsally. Only smaller-billed examples of *turtur* have an angular ridge along the top of the dertrum. An immature from Marion Island (SAFM 559546) has this ridge, but an adult of smaller bill size (SAFM 21881) and an adult of larger bill size (SAFM 55954a) from the same island have larger, evenly rounded dertra. Because many immatures (mainly beach-washed specimens) possess this angular ridge and most adults from all breeding localities have rounded dertra, it seems that the character is usually a sign of immaturity which may persist in some narrow-billed adults. Fleming (1941) stated that width and bulbosity of prion bills develops with age.

There has been much confusion in differentiating *turtur* and *crassirostris*, particularly in beach-washed specimens. The often quoted first Australian record of *crassirostris* (Learmonth 1957) was questioned by Robinson (1972), with whom I agree that it was an incorrect identification. This specimen (NMV B6840) and CSIRO 14670 (which is also alleged to be an Australian *crassirostris* (McKean and Lewis 1971)) are illustrated in Figure 5 for comparison with drawings of specimens from breeding grounds.

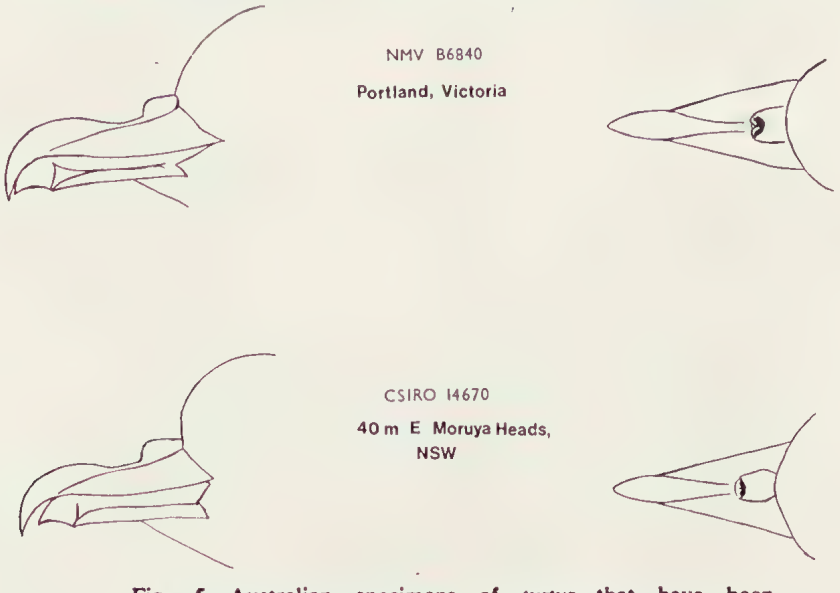

Fig. 5—Australian specimens of *turtur* that have been (erroneously?) identified as *crassirostris*. The lower specimen was prepared with its bill open at the *gape*, giving it a stouter appearance, which possibly resulted in it being wrongly identified. The drawing was made with it clamped shut, which reduced the artificial stoutness.

NMV B6840 more resembles Australian or northern New Zealand *turtur* than other forms, and CSIRO 14670 resembles some specimens from Heard Is. currently classified as *crassirostris*, but often indistinguishable from some *turtur*. Other specimens alleged to be *crassirostris* from Australia that were examined are also incorrectly identified or are not recognisable, including one described by myself (Cox 1976).

Identifications of specimens from breeding colonies have also been doubted. When describing Falkland Is. *turtur*, Strange (1968) said Dr. R. C. Murphy and Dr. D. Amadon had confirmed his identification and furthermore had found the specimens to be inseparable from smaller-billed *turtur* of New Zealand; but Watson (1975), when citing Strange, said either *turtur* or *crassirostris* breeds on the Falkland Is.

Harper and Kinsky (1978) listed both *turtur* and *crassirostris* as breeding on the Falkland Is. Harper said (pers. comm., January 1979) their statements were based on specimens in AMNH and birds seen at sea. However, only one colony is known to exist on the Falkland Is. and specimens from it (detailed below and almost certainly those examined by Harper) are morphological intermediates that have the alleged characters of both taxa. It would be easy to identify individual specimens as either form; but it would not be easy to believe that such specimens could occur in one mixed colony as separate entities.

Bill Characters

Most published descriptions of the bills of *turtur* and *crassirostris* are subjective. Their classification as two species was largely based on such descriptions. The purpose here, in illustrating many of their bills, is to reduce this subjectivity by showing actual bill shapes.

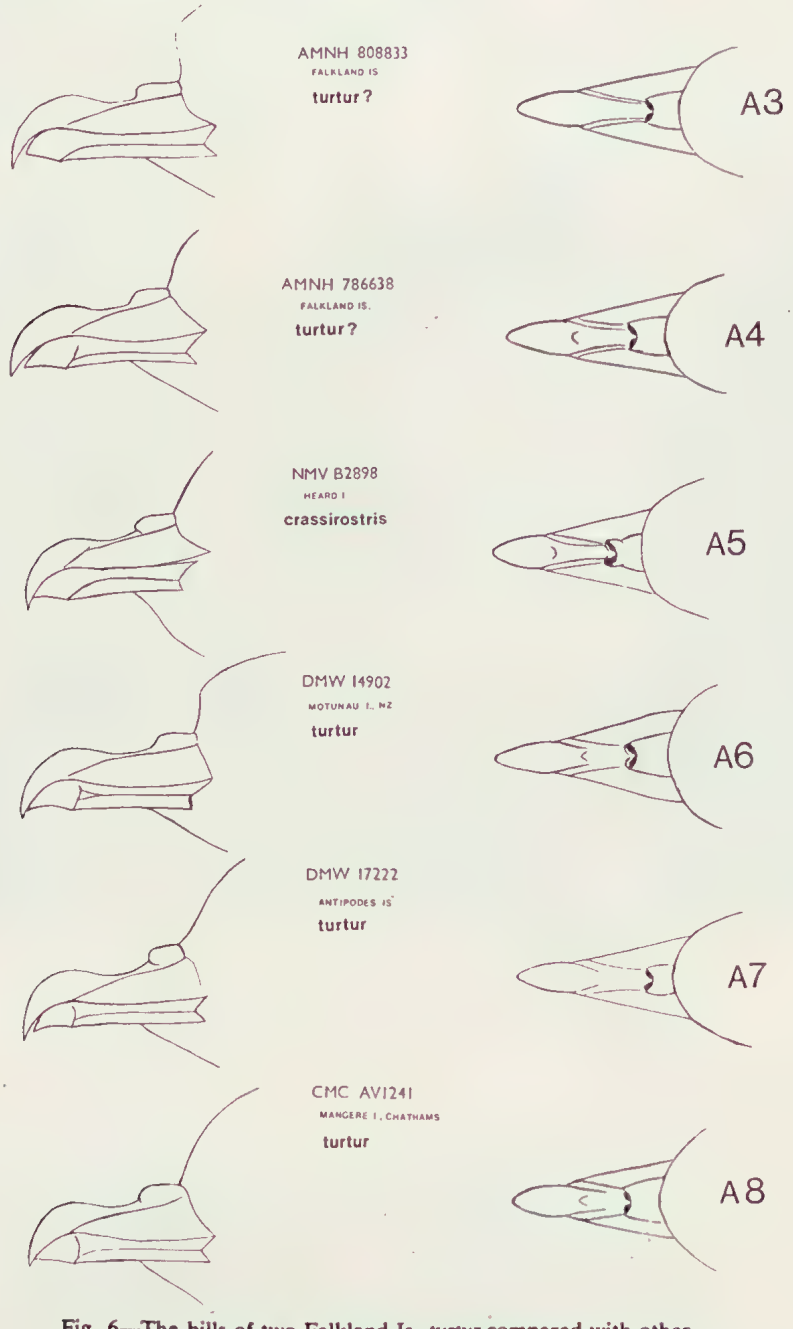

Fig. 6—The bills of two Falkland Is. *turtur* compared with other *turtur* specimens and a Heard I. *crassirostris*.

Two Falkland Is. specimens (AMNH 808833 and AMNH 786638) have bills similar to some Motunau I. (New Zealand) *turtur* (Fig. 6: *cf.* A3, A4, A6). They also closely resemble some Antipodes Is., Mangere Is. (Chathams) and Cook Strait *turtur*, and some Heard I. *crassirostris* (Figs. 6 and 7: *cf.* A5, A7, A10, A11).

Variation in the bills of Heard I. (Figs. 6 and 8: A5, A16, A19) and Motunau I. birds (Figs 6 and 9: A6, A15, A23), and in other populations of which examples are illustrated, shows that it is extremely doubtful whether all *turtur* and *crassirostris* are distinguishable. Some Mangere Is., Antipodes Is. and Motunau I. *turtur* closely resemble some Heard

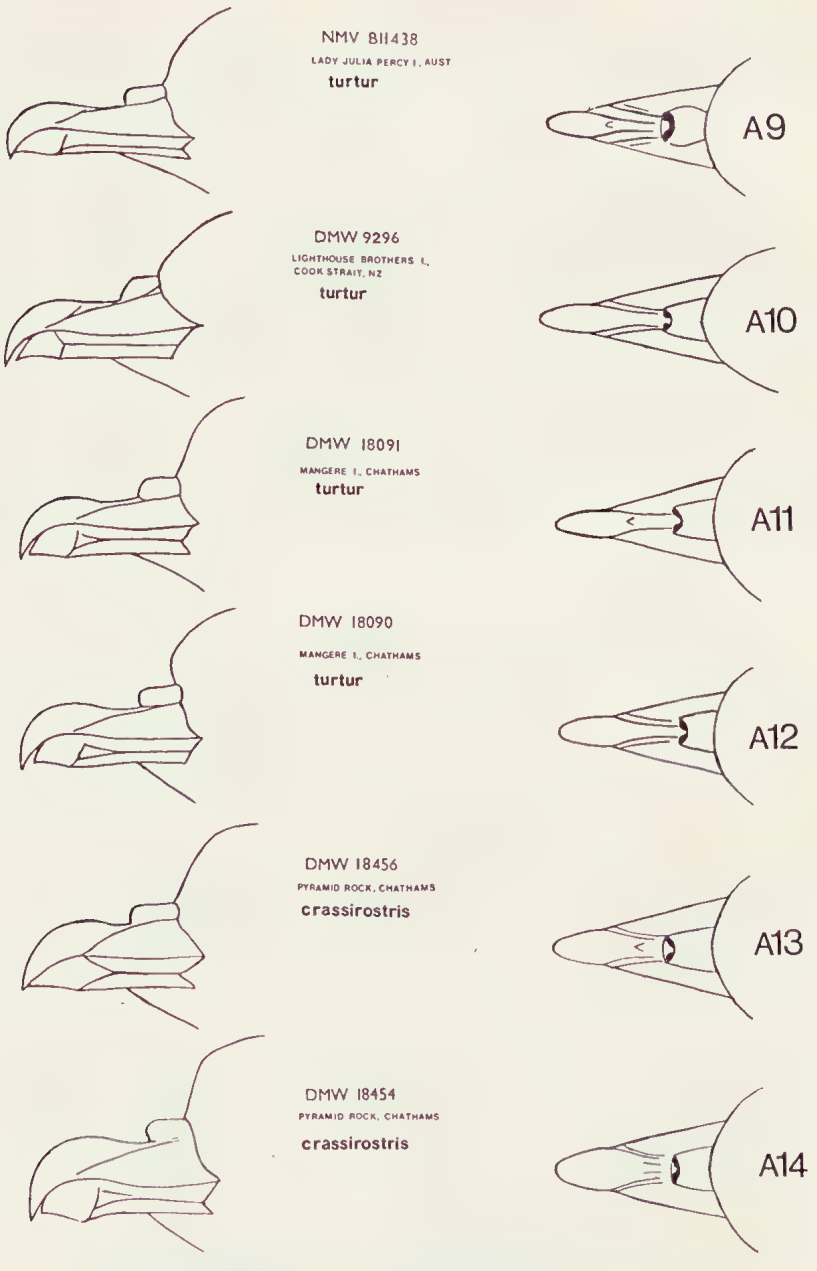

Fig. 7—Two Mangere Is. *turtur* compared with an Australian and a New Zealand *turtur*, and two Pyramid rock *crassirostris*. Mangere Is. specimens have stouter bills than many other *turtur*, and, in bill characteristics, approach the form of Pyramid Rock *crassirostris*. The actual bill lengths of Mangere Is. and Pyramid rock specimens are similar.

and Auckland Is. *crassirostris* (Figs. 6 and 8: *cf.* A5, A6, A7, A8, A15, A16, A17, A18, A19). Some specimens of *crassirostris* from the Bounty Is., Pyramid Rock (Chathams) and Antipodes Is. are very similar to each other (Fig. 10: *cf.* A29, A30, A31), although Falla (1940) recognised each of their populations as a different subspecies. Birds of these populations sometimes also closely resemble Heard and Auckland Is. *crassirostris* (Figs. 8 and 10: *cf.* A19, A20, A27, A28).

While the bill shapes of *turtur* and *crassirostris* cannot be used to distinguish many specimens, of greatest critical interest are the characters of differing populations that breed in close proximity. Fleming (1939) described the largest form of *crassirostris* from the Chatham Group breeding on Pyramid Rock, approximately 17 km from *turtur*, breeding on Mangere Is.

Like most southern New Zealand *turtur*, some Mangere Is. birds closely resemble some *crassirostris* and differ from Australian and northern New Zealand *turtur* by usually having stouter bills with more rounded dertra (Figs. 2, 6 and 7: *cf.* A1, A2, A8, A11, A12). They therefore have somewhat intermediate bill characteristics.

Pyramid Rock *crassirostris* differ from Mangere Is. *turtur* by having broader and deeper bills with more bulbous dertra. But the bills of both vary and differences in the width and depth correspond to the size of their dertra. The actual bill lengths of both forms are similar, as illustrated in Figure 7 (A11,

A12, A13, A14), which also shows that their bill differences are not always significant.

Dimensions of Fairy Prions

The dimensions of specimens examined and those listed by Buddle (1941), Despin *et al.* (1972), Falla (1937, 1940), Fleming (1939), Richdale (1944) and Wood-Jones (1937) are compared in Figure 11, which shows mean and range of measurements. Although few specimens are known from some breeding grounds, the dimensions of birds from some separate localities clearly differ. Notably, Pyramid Rock *crassirostris* have absolutely longer wings and wider and deeper bills than Mangere Is. *turtur*. Also, Bounty Is. *crassirostris* is not a small form as stated by Condon (1975), because, though smaller than Pyramid Rock birds in mean bill and wing measurements, its dimensions are all greater than those of Heard I. and Auckland Is. *crassirostris*.

Differences between the mean dimensions of 15 Pyramid Rock and seven Bounty Is. *crassirostris* (0·5 bill-depth, 0·9 bill-width, 0·9 culmen, 5·5 wing length) are so small that they are unlikely to have much taxonomic significance (especially because the data are from only 22 specimens) and surely constitute insufficient evidence for subspecific differentiation as Fleming (1939) proposed by naming Pyramid Rock birds *P. c. pyramidalis* after examining only 14 specimens. Furthermore, although there is no evidence that the specimens represent random samples of each population, the

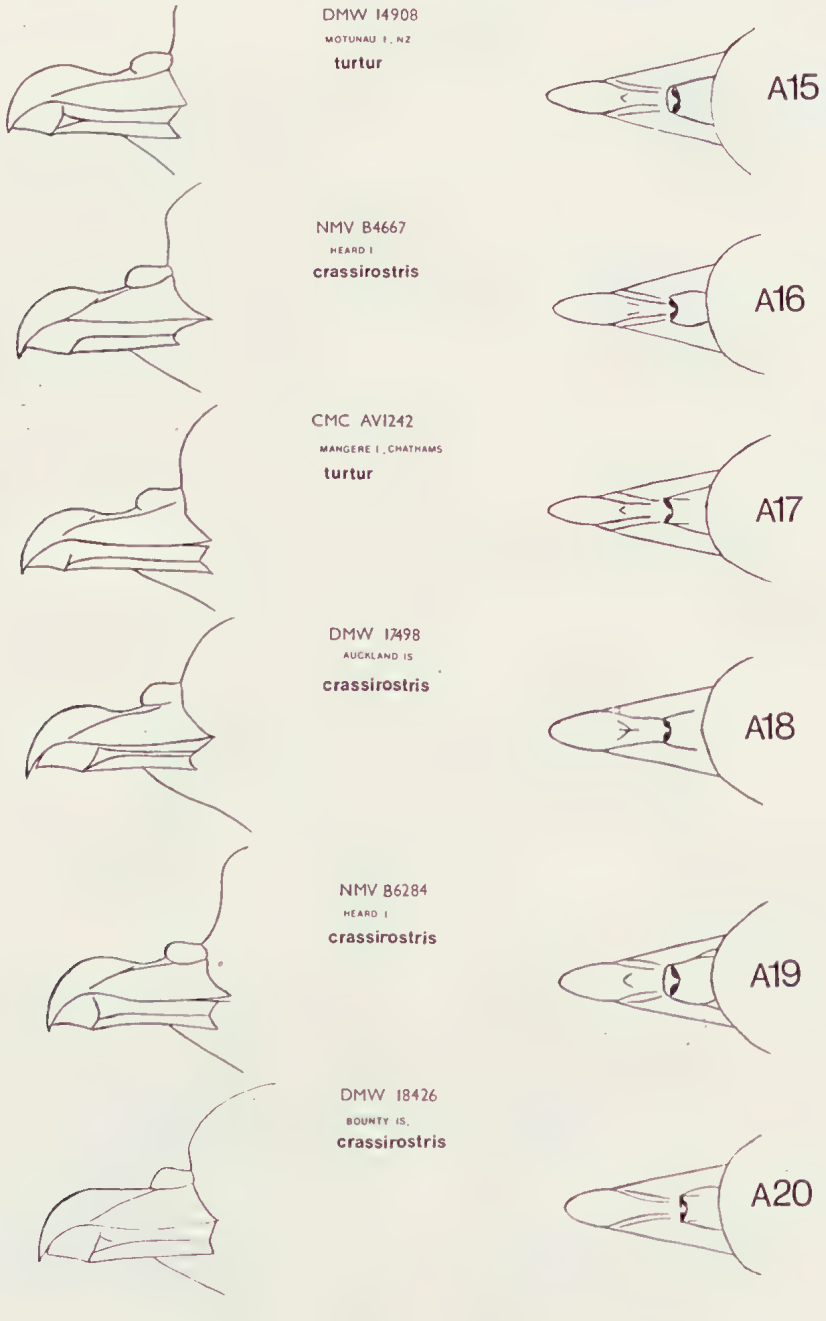

Fig. 8—Heard I. *crassirostris* (A16) have bills very similar to Motunau I. and Mangere I. *turtur*, or (A19), very similar to Auckland Is. and Bounty Is. *crassirostris*.

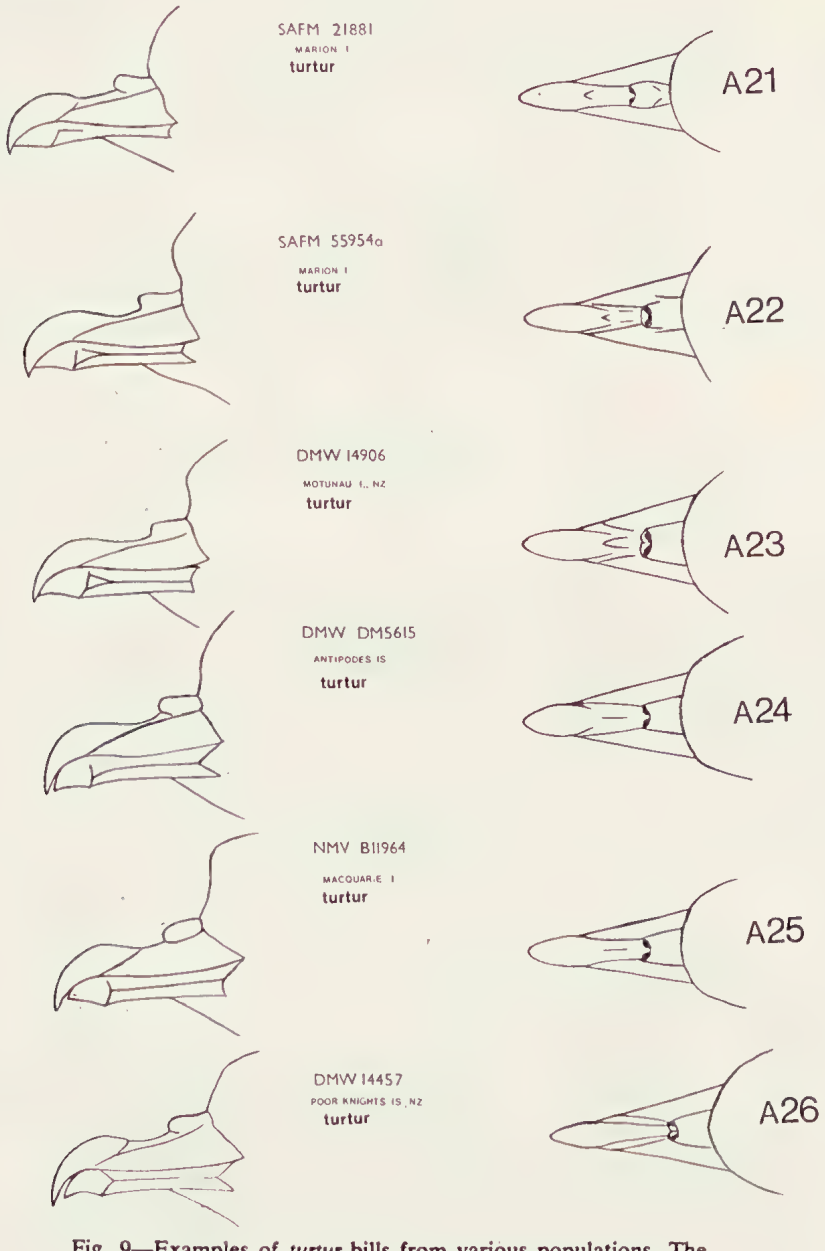

Fig. 9—Examples of *turtur* bills from various populations. The similarity of these specimens suggests that races cannot be distinguished by bill characteristics.

means of the bill width, bill depth, culmen and wing measurements of four *crassirostris* from Pyramid Rock and seven from Bounty Is. were tested on the hypothesis that for each character the means of the two populations would be equal. This was done with a *t*-test after assuming that each of the four characters is normally distributed in both populations and also after having tested the hypothesis, again for each character, that the variances from both populations would be equal (Table 1). At the conventional 95% level, bill width was the only character for which the means were found to significantly differ. However, because this character is only indicative of a very small difference between the populations, and the samples were extremely small, with the added problems such as measuring the bills so finely, it is felt that it would be premature at this stage to attach any nomenclatural significance to the statistical result.

The two specimens of *crassirostris* alleged to be from the Antipodes Is. are also better classified with Pyramid Rock and Bounty Is. birds, for their bills have very similar proportions but are slightly narrower, suggesting immaturity. Also, one (CMC AV1247) is otherwise doubtfully distinguishable from some Bounty Is. specimens, while the other (CMC AV1208, Fig. 10: A29) only differs from specimens of both populations by having shorter wings (by 4·0). However, their age when collected cannot be established, because the collecting dates are unknown; only one (male) is sexed, without mention on its label of gonadal condition, and, judging from plumage condition, they are old and have been handled frequently; consequently, plumage wear is difficult to ascertain. If they are immature (therefore non-breeding) the shorter wings of one have little bearing on their classification.

TABLE 1

	Pyramid Rock n = 4 Mean (Range)	Bounty Islands n = 7 Mean (Range)	Variances	F	t_9	Significance
Bill depth	8·58 (8·2-8·7)	8·17 (7·8-8·8)	Equal	1·64	2·156	0·1>P>0·05
Bill width	12·45 (11·8-12·9)	11·07 (10·3-12·6)	Equal	3·33	3·00	0·02>P>0·01
Culmen	23·35 (22·7-24·3)	22·79 (21·6-23)	Equal	1·87	1·44	P>0·1
Wing	192·5 (190-194)	187·57 (180-197)	Equal	8·99	1·63	P>0·1

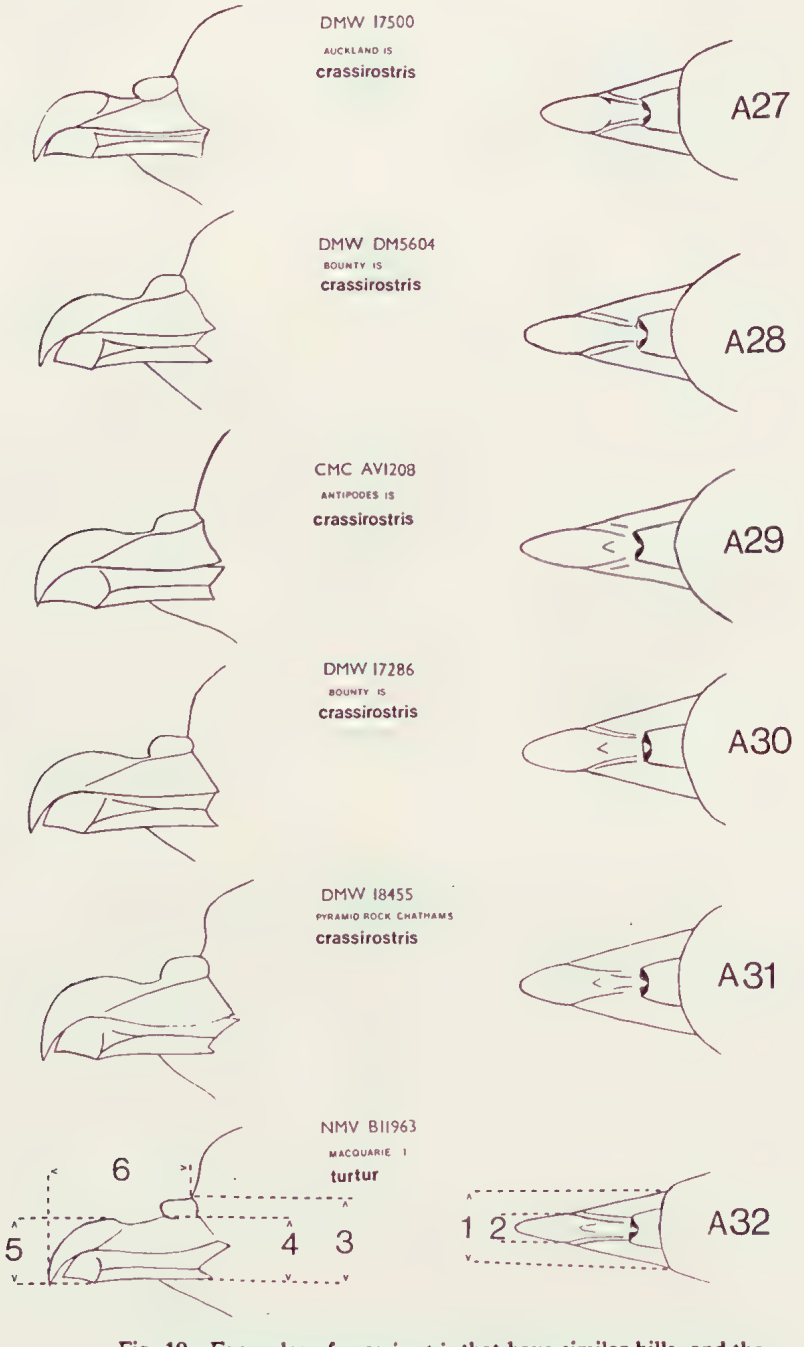

Fig. 10—Examples of *crassirostris* that have similar bills, and the dimensions numbered on A32 correspond to the measurements given in Table 2.

Most Pyramid Rock, Bounty Is. and Antipodes Is. *crassirostris* can be separated from all other fairy prions by having a bill depth of over 8·0; but Heard I. and Auckland Is. birds present a difficult problem because they appear to be intermediates. Many have stout bills, thus closely resembling *crassirostris* or some *turtur*, but the dimensions of specimens are closer to those of *turtur* (Fig. 11).

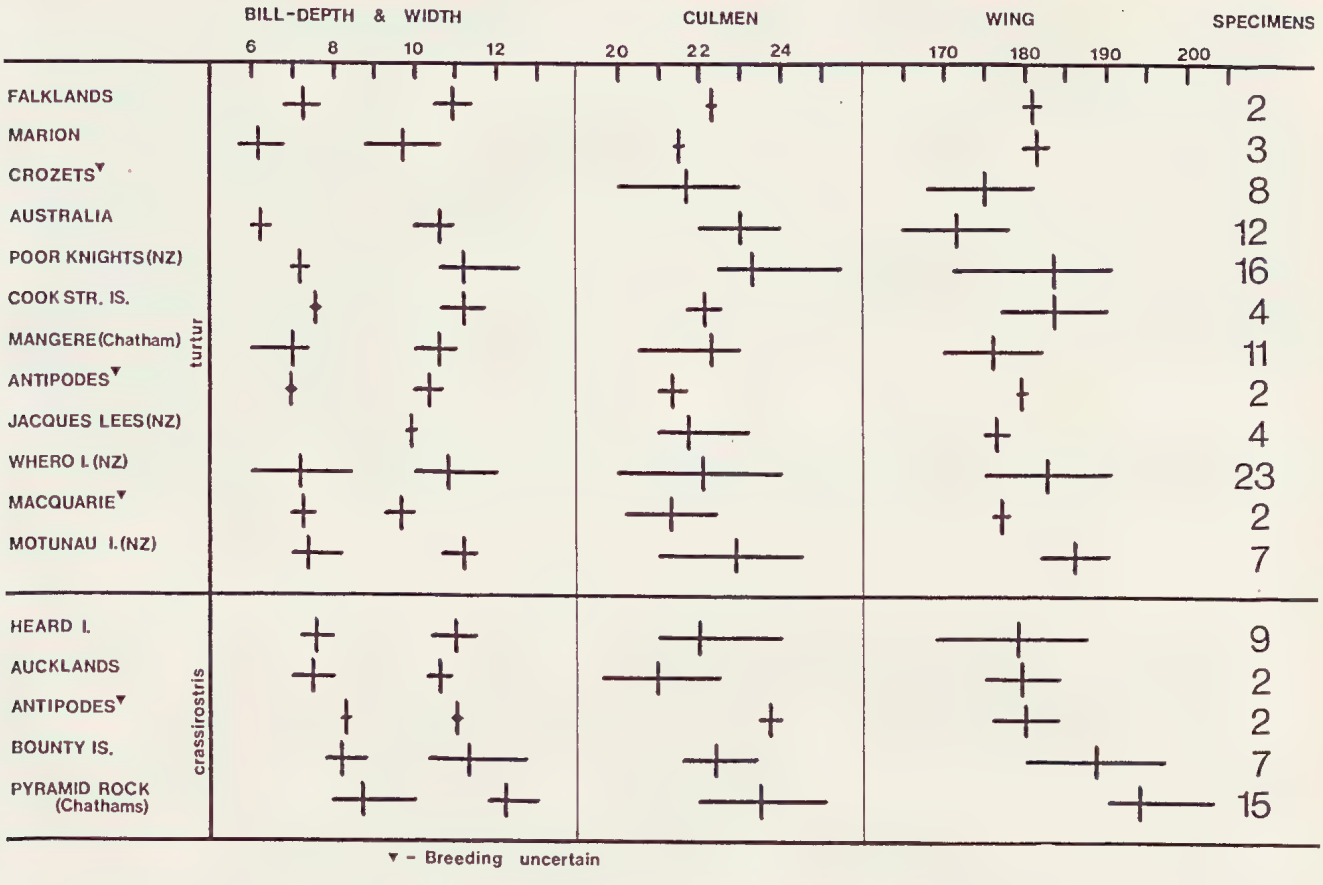

Fig. 11—Dimensions of fairy prions (mean and range).

Falkland Is., Marion I., Australian and New Zealand *turtur* specimens have slight dimensional differences, but more material is needed before assessments of their relationships can be made. Falla *et al.* 1966 said Antipodes Is. *turtur* are a small subantarctic race, but the few specimens of uncertain natal origin are similar to many other *turtur* (Figs. 8 and 9: A7, A24) and cannot be recognised as distinct. The type of *fallai*, taken at sea near South I., New Zealand, is a young bird just out of nestling down (Falla 1940) and also cannot be recognised.

THE WHALE-BIRDS

Although it is extremely difficult, if not impossible, to distinguish many *desolata* from *salvini*, Falla (1940) and Fleming (1941) followed Mathews (1912) in listing *belcheri* and *desolata* in a separate subgenus from *salvini* and *vittata*. Fleming gave the subgeneric characters of *belcheri* and *desolata* as: "Long bill with straight outlines, viewed from above. Palatal lamellae become obsolete some distance behind the dertrum and are invisible when the bill is closed. Plumage pale grey, and head pattern moderately distinct," and those of *salvini* and *vittata:* "Large very broad bill with bowed outlines. Palatal lamellae extending all the way from gape to dertrum and visible even when bill is closed. Plumage dark and head pattern well defined." He also said, "the reality of the subgeneric grouping can be emphasised by drawing the bill of one species in a network of Cartesian co-ordinates, and by representing the same co-ordinates on similar drawings of other species." By this method he suggested that *belcheri* and *desolata* have bills based on a different "plan" to those of *salvini* and *vittata*.

However, the plumage characters (detailed previously) of *desolata* and *salvini* are not different and the bill characters of both intergrade, indicating that the subgeneric grouping is wrong. Furthermore, Fleming's representation of the bill of *desolata* in Cartesian co-ordinates is not true of most *desolata*, because only a minority (typically îles Kerguelen birds) have straight cutting edges to their upper mandibles as he depicted. Their bills in fact usually have curved cutting edges (beneath which their lamellae are often visible) and are very similar to those of *salvini* (Figs. 14 and 15: *cf.* B15, B17, B19, B20, B21, B23, B24). Many *desolata* also have bowed bill outlines viewed dorsally (Figs. 12, 14 and 15: B13, B16, B19, B21, B22) and their lamellae are often visible when the bill is closed (also see Tickell 1962) and usually extend inside the bill as far as the dertrum. The lamellae in *desolata, salvini* and *vittata* are large at the gape and progressively diminish in size towards the dertrum, as described by Murphy (1936) for *vittata*, but in narrower-billed *desolata* specimens they are usually present only as rudimentary ridges towards the dertrum and closely resemble those of *belcheri*, also described by Murphy. Irrespective of natal origin, adult specimens of *desolata, salvini* and *vittata* with wider and more bowed bills also tend to have larger lamellae.

In whale-birds the major problems are in recognising *belcheri* from some *desolata*, and recognising *desolata* and *vittata* from *salvini*.

Bill Characters of Narrower-billed Whale-Birds

Although bill measurements of allopatric populations of *belcheri* and *desolata* overlap slightly, both forms are clearly separable except in their populations of Îles Kerguelen and Île de l'Est, Archipel Crozet.

Falla (1937) identified Îles Kerguelen *belcheri* and *desolata* by bill shape and said specimens of each form with "exactly the same" bill dimensions could only be recognised by the "compression of the maxillae in *P.belcheri* and consequent slight concavity of outline when viewed dorsally." He described two *desolata* populations on the archipelago: A—a wide-billed form, and B—a narrow-billed form. Of form B he said that "At the time of collecting I regarded these birds as a new form and a possible hybrid between *P.desolata* and *P.belcheri*, but subsequent examination of the specimens shows that they possess none of the distinctive characters of *P.belcheri*, and are certainly referable to *P.desolata*." Tickell (1962) used Falla's measurements from these two forms and concluded that Îles Kerguelen *desolata* are a narrow-billed subspecies.

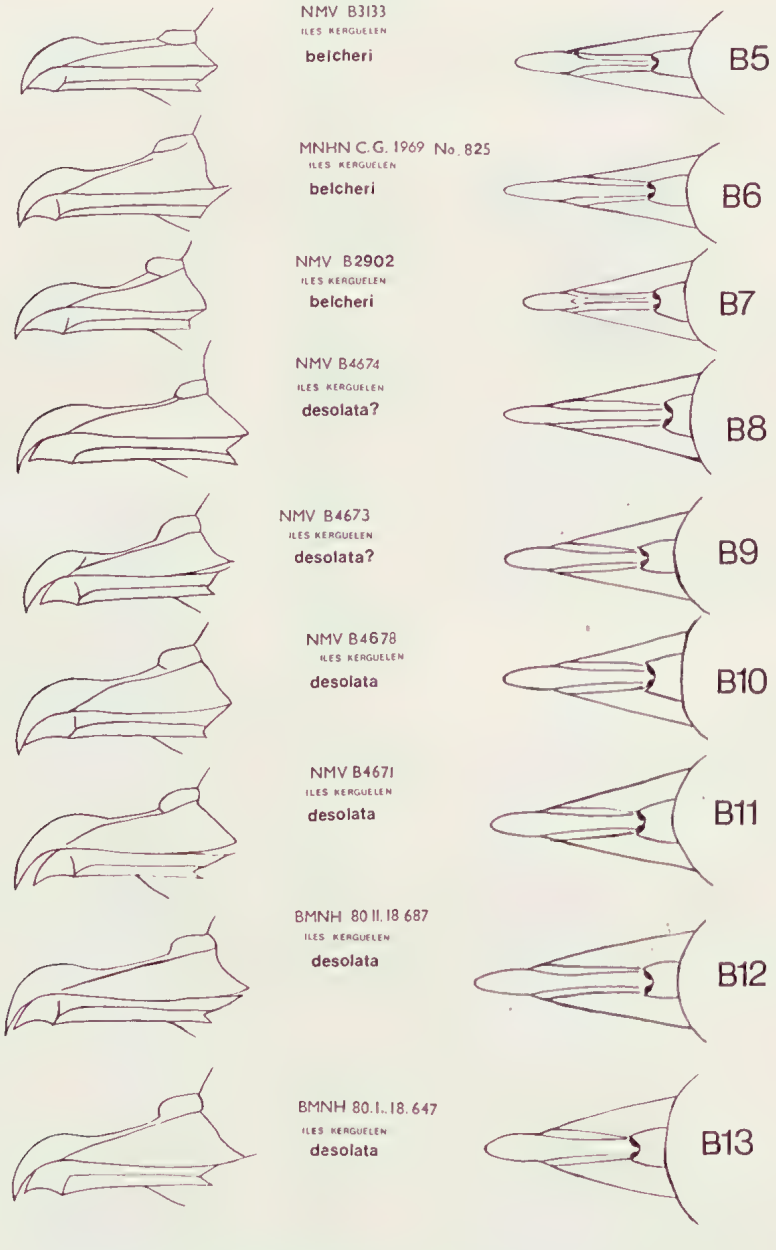

Fig. 12—The intergradation of bill characteristics of *belcheri* and *desolata* of Îles Kerguelen.

The bill dimensions of all three forms from Îles Kerguelen and *belcheri* from the Falkland Is. are plotted separately in Figure 13, which also shows the means and range in bill size of other *desolata* (from Tickell 1962), and the known bill size variation of *belcheri*. There is little difference between Îles Kerguelen form A and *desolata* of other breeding localities in the mean or variation of bill size. Form B is intermediate between form A and *belcheri* (i.e. intermediate between *desolata* and *belcheri*).

The bill shapes of Îles Kerguelen *belcheri* and *desolata* are also variable, and this variation is shown by drawings of their bills in Figure 12 (B5-B13). Some *desolata* have bowed outlines to their bills (B12, B13) while others have straight outlines (B10, B11). Some *belcheri* do not show a slight concavity in their dorsally viewed bill outline; NMV B3133 (B5) with a bill width of 8·7 has a slightly bowed outline. Falla (1937) did not elaborate on "the distinctive characters of *P.belcheri*" beyond their bill shape, and

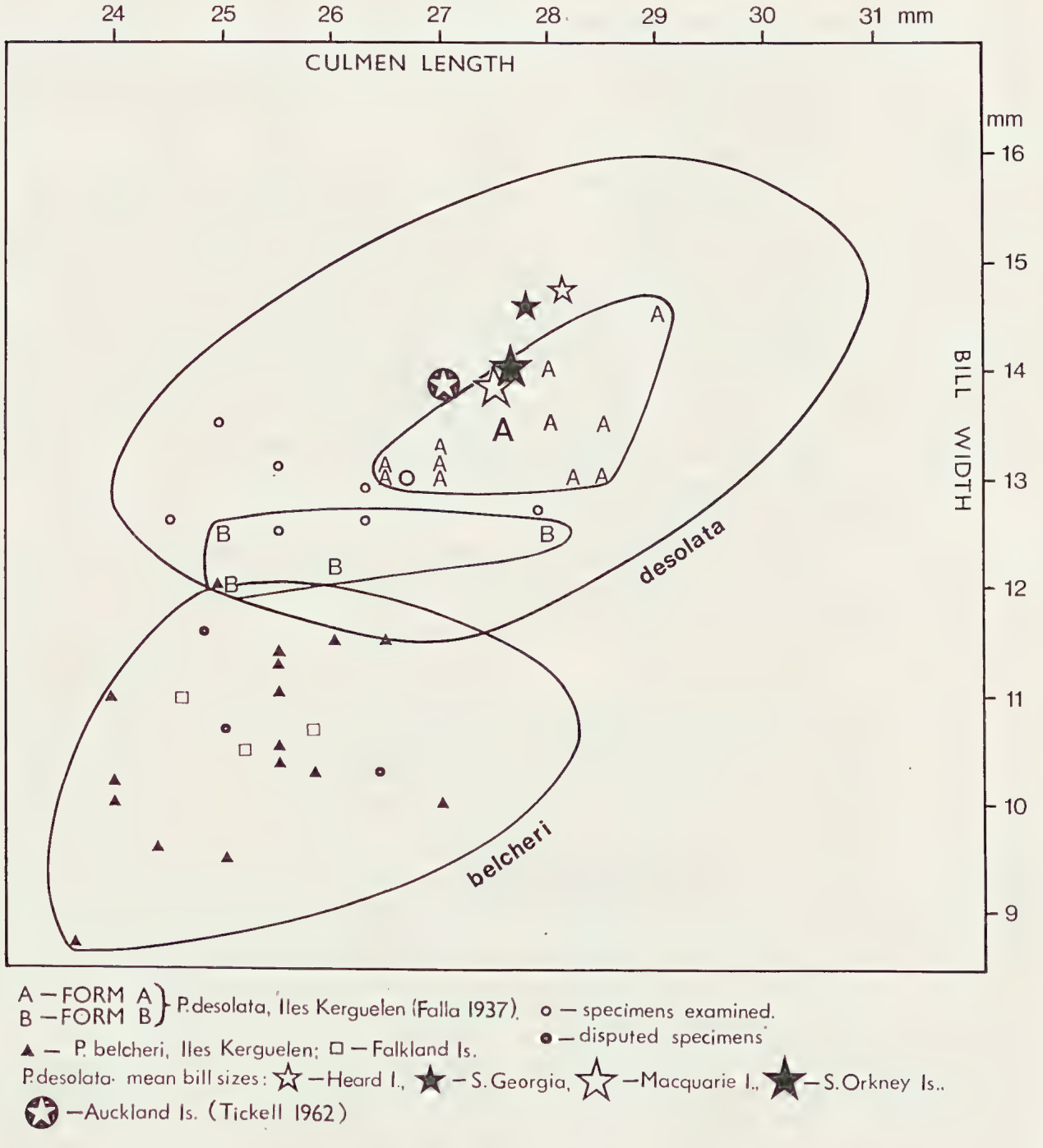

Fig. 13—Bill dimensions of *belcheri* and *desolata*. Solid lines illustrate the known size variation of each form, and keyed symbols the size of individual specimens. Note the bill size of Îles Kerguelen form B is intermediate between form A and *belcheri*, and that form A is similar in mean bill size to other *desolata* populations.

it seems that he only found concavity in the bill outlines of his specimens once they had dried. Also, live and fresh beach-washed specimens I have collected had no indication of concave bill outlines but, when dried, concavity was noticeable. Concavity in bill outline can be caused by shrinkage and consequent inward contraction of the latericorns on drying specimens. BMNH 1932.7.2.17 (fig. 2: B2) has its bill slightly swollen at the base and slightly concave towards the dertrum; a condition probably caused by shrinkage.

Differences between îles Kerguelen *belcheri* and *desolata* are ill-defined, and it is not surprising that the identifications of some specimens have been disputed. NMV B4673, NMV B4674 and NMV B4676 are labelled *desolata* from îles Kerguelen (by the collector?) but also written on their labels is P. C. Harper's opinion that they are *belcheri*, which is indicated as correct by the plots of the specimens in Figure 13. However, the collector also obtained other *desolata* at the same locality on the archipelago (NMV B4671, NMV B4672, NMV B4675 and NMV B4678), and because the drying bills of some specimens shrink more than others, the question remains whether îles Kerguelen birds can be identified when living. Kinsky and Harper (1968) stated that under controlled drying conditions the bill width of adult *belcheri* shrinks by 5 to 16 per cent (average 13 per cent). This wide variation in shrinkage suggests that at least one of the disputed specimens (NMV B4673) could have been quite justifiably identified as *desolata* when collected; it does not have concave bill outlines viewed from above, and on the dried skin its bill width measures 11·6, which is within the range of variation of both forms.

Tickell (1962) found îles Kerguelen *desolata* to be narrower in bill width than other *desolata* because he combined the dimensions of forms A and B in his calculations. But form A closely resembles other *desolata*, whereas form B is intermediate between *belcheri* and *desolata*, and other specimens from the archipelago show there is intergradation of the characters of both forms. This evidence suggests hybridization and, consequently, îles Kerguelen *desolata* should not be classified as a separate subspecies.

The measurements of two *belcheri* from île de l'Est given by Despin *et al.* (1972) are: bill width 10·2 and 11·8, culmen length 25 and 27. Two *desolata* from the same colony measure 12·5 and 14·3, and 26 and 28. Despin *et al.* said of the *belcheri* colony:'Cette colonie est de trés petites dimensions —elle ne compte que quelques nids—et trés nettement délimitee' (This colony is very small—only a few nests—and extending over a very limited area). No other *belcheri* were found on the island. Furthermore, they said: "Le Prion de la Désolation est apparemment trés peu abondant áL'Ile de l'Est où une seule colonie a été observée, la même d'ailleurs que celle du Prion de Belcher mentionée précédemment" (The Desolate Prion is apparently very scarce on East Island where only one colony has been observed, the same colony moreover as that of Belcher's Prion mentioned above). Because of the scanty data few conclusions can be formed. Nevertheless, the culmen lengths of the two forms overlap, and the difference in bill width between the largest *belcheri* and the smallest *desolata* is only 0·7. When the specimens were examined, the two forms could not be separated by plumage coloration, though plumage wear varied, and it was noted that their dorsally viewed bill outlines intergraded. The smallest *belcheri* (MNHN C.G. 1974 No. 1823) has very slightly concave outlines, while the largest (MNHN C.G. 1974 No. 1824) has straight though slightly swollen outlines. The smallest *desolata* (MNHN C.G. 1974 No. 1816) has very slightly bowed outlines, and the largest (MNHN C.G. 1974 No. 1815) has obviously bowed outlines. It is interesting that the former two are both females, and that the latter are both males. In bill shape the two *desolata* are intermediate between the *belcheri* and *salvini* (MNHN C.G. 1974 Nos. 1808 and 1809) that are also from île de l'Est. Therefore, as on îles Kerguelen, the bill characters of île de l'Est *belcheri* and *desolata* are inconsistent.

Bill Characters of Wider-billed Whale-Birds

Bill dimensions of 245 specimens are shown in Figure 16, which is a reduced continuation of Figure 13. In most cases smaller-billed *desolata* were excluded if their identification from *belcheri* was doubtful. The known dimensional limits of *desolata*, *salvini* and *vittata*, derived from specimens and measurements given by Despin *et al.* (1972), Falla (1937, 1940), Mathews (1912, 1938), Murphy (1936), Serventy *et al.* (1971), Swales (1965) and Tickell (1962) are superimposed around the plots of the individual specimens, and the mean bill dimensions of separate breeding populations are given except those of *desolata*, which are shown in Figure 13. Figure 16 shows that *(a)* there is wide overlap in bill dimensions of the three forms; *(b)* many specimens have intermediate dimensions; *(c)* there is a strong tendency for birds with a longer culmen to have a wider bill; and also that *salvini* is an intermediate form between *desolata* and *vittata*.

Falla (1940) and Fleming (1941) recognised two subspecies of *salvini* (nominate *salvini* of Marion I. and *crozeti* of Archipel Crozet) because the specimens available to them suggested that Marion I. birds have larger bills. However, Despin *et al.* (1972) later showed that île de l'Est *salvini* have larger bills (culmen 29-34 (av. 31·6), and bill width

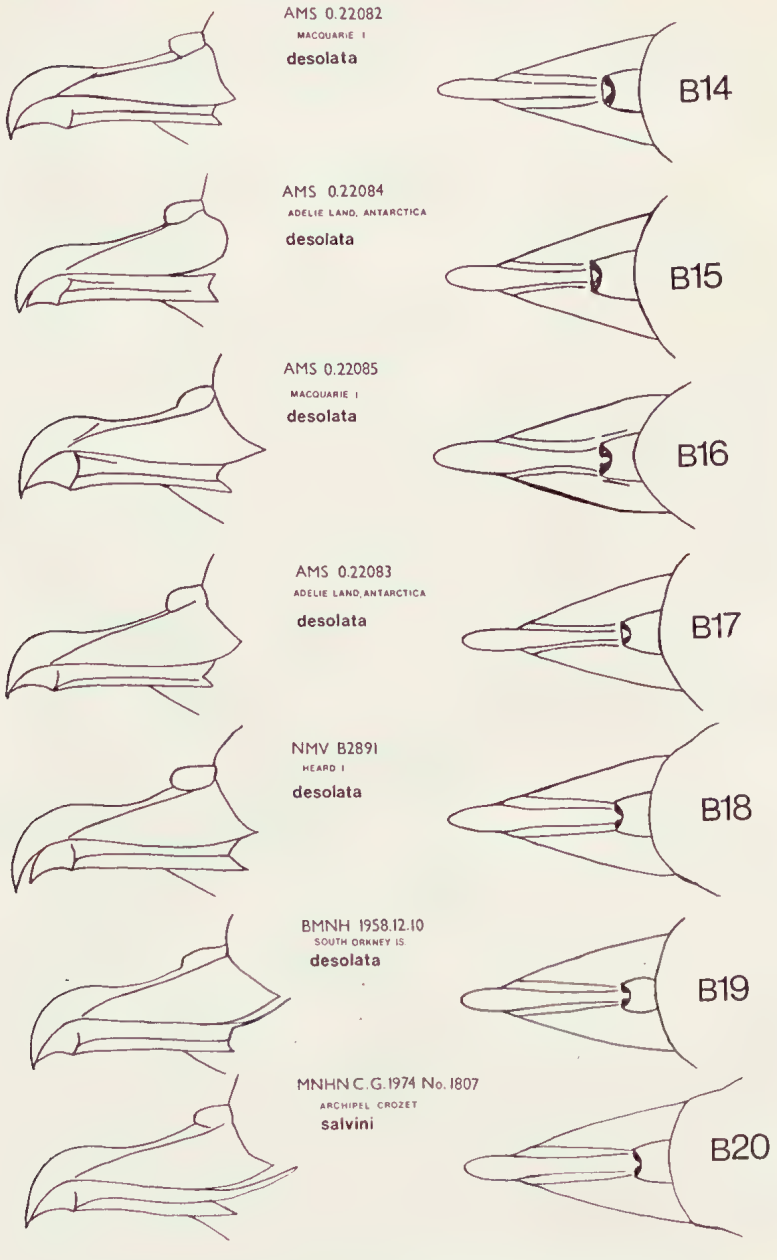

Fig. 14—Typical *desolata* specimens from various populations compared with a *salvini* specimen. Note that the cutting edge to the upper mandible of *desolata* is usually curved upwards at the base, in profile view, as in *salvini*, and that *desolata* frequently have bowed bill outlines, viewed dorsally.

15·5-20·5 (18·4) on fresh specimens). It is possible that *vittata macgillivrayi* is intermediate between *salvini* and *vittata* (Elliott 1957; Clancy 1965), but in bill shape two specimens from île Saint-Paul more resemble *vittata*. Their measurements and those of two others given by Mathews (1938) and Falla (1940) are: culmen 30-31 and bill width 17-18. Fifteen presumed beach derelicts measured by Serventy *et al.* (1971) are 29·5-34·5 (av. 32·3 ad 16·2-21·5 (18), and appear smaller than *vittata* which they measured as 32-37 (34) and 18·8-22·6 (20·6), but the overlap in size indicates that many specimens are not separable. The bulge in outline of dorsally viewed *vittata* bills is variable, with some being more evenly bowed (Fig. 15: *cf.* B27, B28), and although *macgillivrayi* also have a similar bill shape (B25, B26) the bulge in bill outline is also present in some *salvini* and even some *desolata* (Figs. 14 and 15: B16, B22). Differences in bill profile between *salvini* and *vittata* suggested by Fullagar (1972) are inconsistent (Fig. 15). The dertra of *salvini* and *vittata* do appear "weak" (Falla 1940) in proportion to bill size compared with those of *belcheri* and *desolata*, but in these whale-birds it appears that differences have evolved through spreading latericorns and palates without a corresponding enlargement of the dertra and nasal tubes. In all the wider-billed whale-birds the dertra and nasal tubes are of similar size, but with individual variation (Figs. 14 and 15).

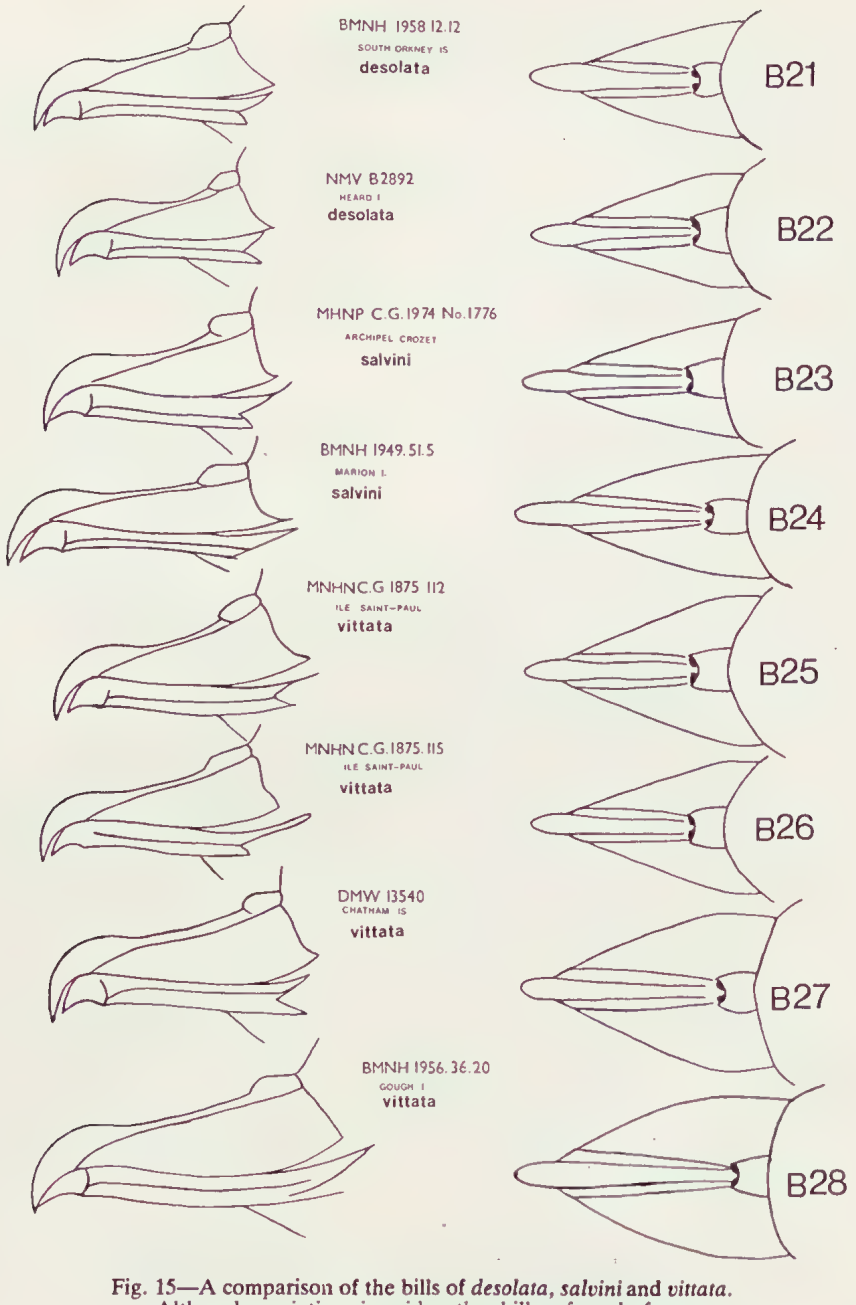

Fig. 15—A comparison of the bills of *desolata*, *salvini* and *vittata*. Although variation is wide, the bills of each form are fundamentally similar. B28 has a bill that is larger than that of average sized *vittata*.

A further bill characteristic used to separate *salvini* and *vittata* is colour. Watson (1975) said the bill colour of *salvini* is "wholly blue" and that of *vittata* is "steel gray", a difference accepted by most writers. However, Murphy (1936) said the bill of *vittata* is "light blue or bluish grey" and two males collected on Gough I. in April have their bill colours labelled as "blue-grey" (BMNH 1956.36.20) and "blue" (BMNH 1956.36.19). Falla (1937) said New Zealand *vittata* have the upper bill "glistening iron grey, with an occasional bluish patch appearing as an abnormal marking." Although there is variation, it seems possible that *vittata* of the southern Atlantic region differ slightly in bill colour from New Zealand birds. But confusion could stem from the fact that after death the bills of both forms rapidly become blackish. Specimens of *desolata* and *salvini* that I have collected on beaches have had entirely blackish bills and eyes not yet shrunken. Narrower-billed whale-birds on the other hand, have bills which do not usually turn blackish until they are dry.

Although Falla (1940) and Fleming (1941) said *salvini* is more closely related to *vittata* than to *desolata*, and Clancy (1965) and Watson (1975) listed *salvini* and *vittata* as conspecific, there appears to be no reason, by way of bill size or structure (their criteria) to support these views. It seems that *salvini* consists of an assemblage of slightly differing populations which are intermediate between *desolata* and *vittata* (Fig. 13).

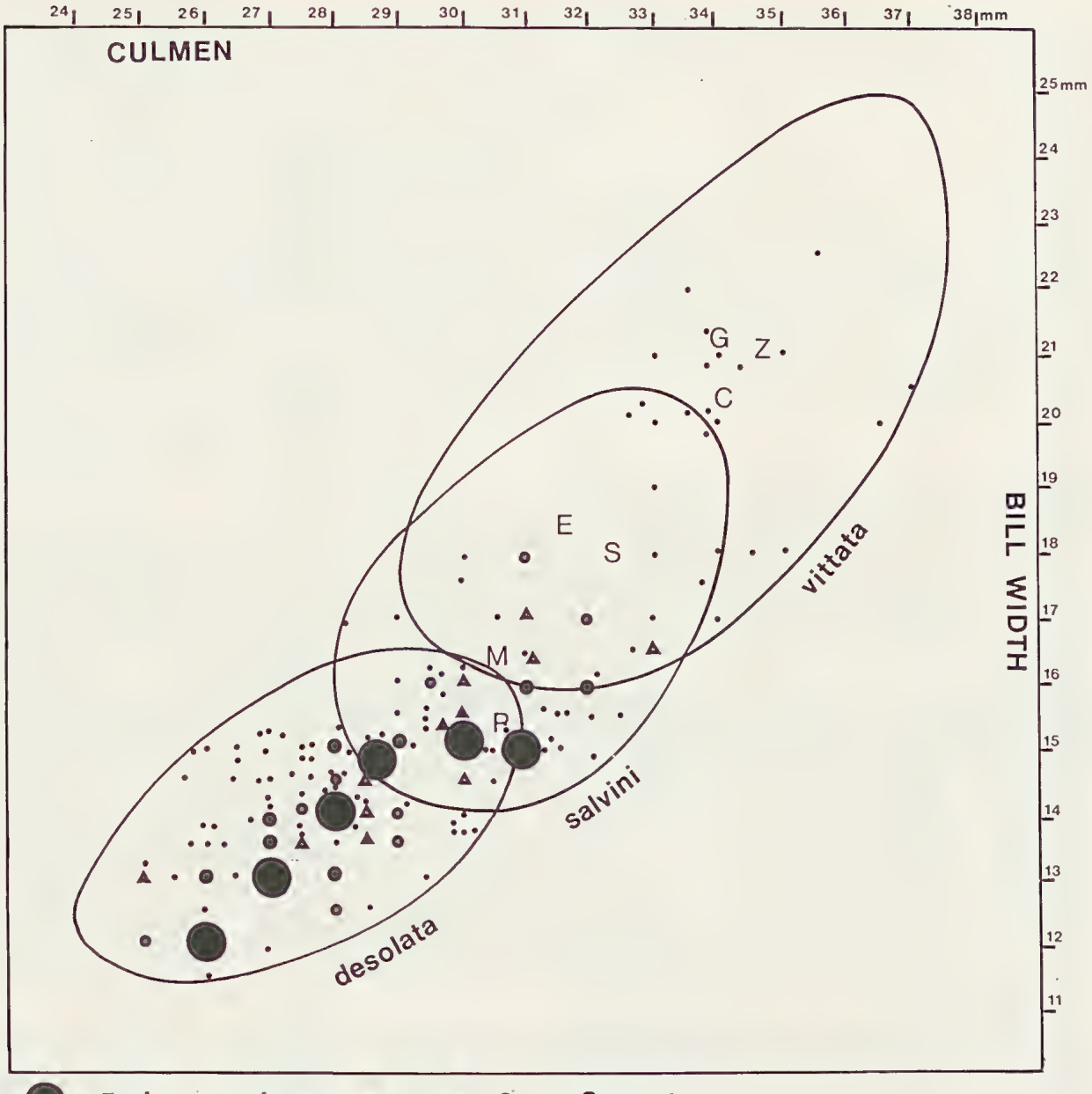

Fig. 16—Dimensions of the bills of *desolata*, *salvini* and *vittata*. The known size variation of each form is superimposed around the plots of individual specimens. the mean bill sizes of *salvini* and *vittata* populations are shown; those of *desolata* are shown in Fig. 13. Note the wide overlap in the bill dimensions of each form, and that many specimens are intermediate. Unlike *desolata*, and *vittata*, bill sizes of different *salvini* populations are inconsistent.

Other Characters of Whale-Birds

Bill, tarsus, tail and wing measurements of specimens from breeding localities are shown in Figure 17, the data derived from specimens examined and measurements given by Despin *et al.* (1972), Falla (1937, 1940), Mathews (1912, 1938), Murphy (1936), Rand (1954), Swales (1965) and Tickell (1962). The dimensions of each recognized species overlap with those of one or more of the other three, and differences are hard to define. There is a tendency for larger-billed birds to have their other dimensions larger, but this generalization does not always hold true.

Some *belcheri* have the shortest wings but their measurements widely overlap those of *desolata*. However, *belcheri* usually have a longer tarsus than those *desolata* which have only slightly larger bills; but two specimens of each form collected on île de l'Est by Despin *et al.* (1972) differ from most other *belcheri* and *desolata* in having a longer tarsus. In

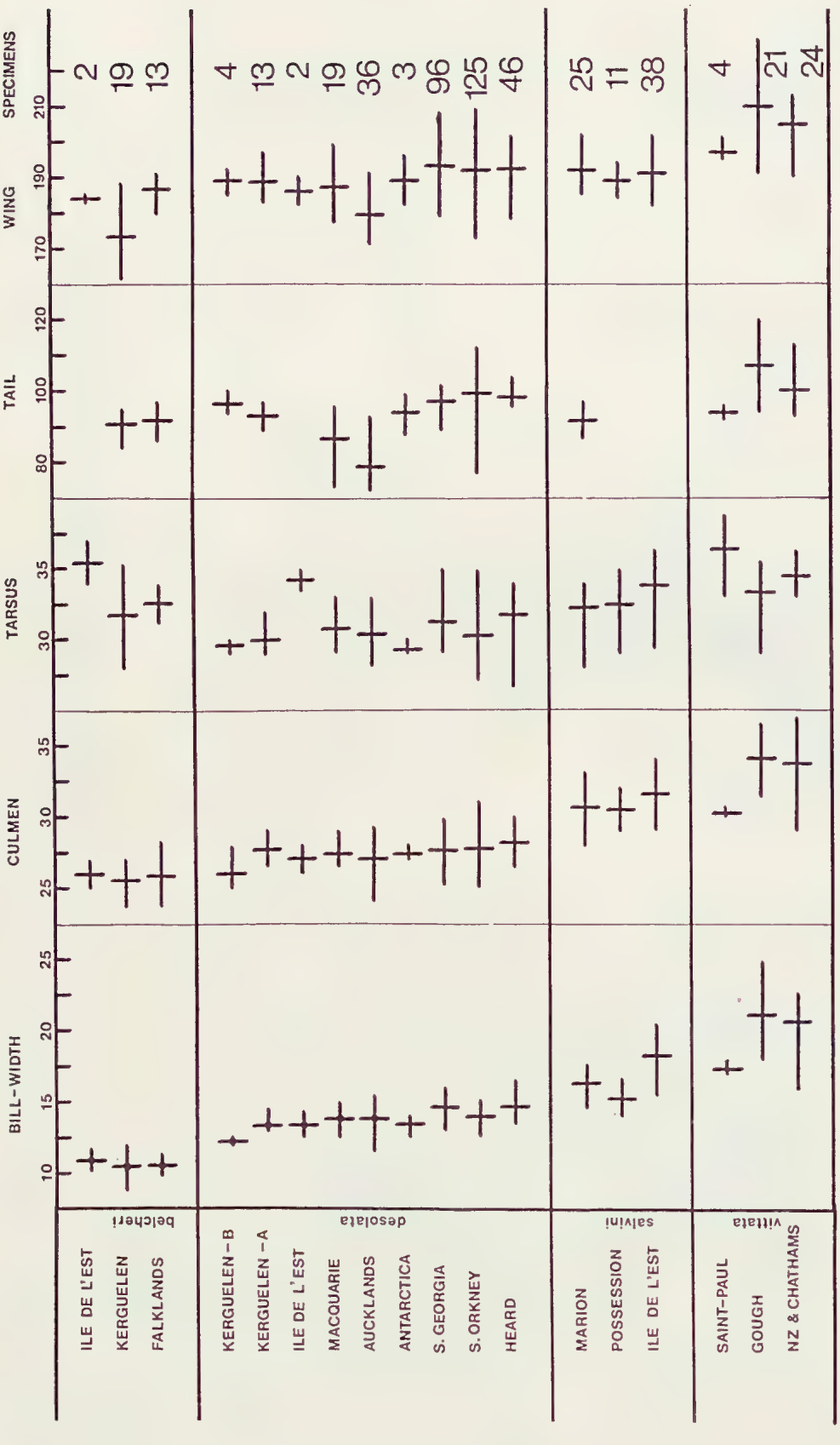

Fig. 17—Dimensions of whale-birds (mean and range).

tarsus measurement the île de l'Est birds more resemble each other than other populations of each form. Furthermore, both forms from this small colony have similar wing lengths, and in all other given dimensions the *desolata* are intermediate between the *belcheri* and *salvini* of the same island. Therefore, there appears to be little convincing evidence that at the two localities (île de l'Est and îles Kerguelen) where *belcheri* and *desolata* both breed they are morphologically distinct; although their allopatric populations show fairly clear interspecific differences. At the Falkland Is., where *belcheri* is the only breeding form, they are distinct from *desolata* by their bill width, which is not known to exceed 11·5. Most *desolata* can be distinguished by having a wider bill and a shorter tarsus.

Tickell (1962) classified South Georgia, S. Orkney Is. and Heard I. *desolata* as a different subspecies from Macquarie I. and Auckland Is. birds because they have differences in wing and tail lengths. Nevertheless, these differences are slight and are probably not indicative of subspecific distinction, because Macquarie I. *desolata* are intermediate in wing and tail length between Auckland Is. and Cape Denison (Antarctica) *desolata,* and the latter are intermediate between Macquarie I. and Heard I. birds. Moreover, Macquarie I. birds more resemble Heard I. *desolata* in wing length than birds of the Auckland Is. Therefore only a minority of individuals are likely to be identifiable, and Tickell's classification of subspecies should be treated with caution.

The longest-winged birds are *vittata,* but their wing measurements overlap those of *salvini* by 12 and *desolata* by 19. Most *vittata* are nevertheless distinguishable by the combination of long wings and large bill, because most longer-winged *desolata* have measurably smaller bills. There is little difference in the bill sizes of Tristan da Cunha, Gough I. and New Zealand *vittata* (Falla 1940, Elliott 1957) and, except for forms of the southern Indian Ocean region, all *desolata* populations have similar mean bill sizes (Tickell 1962, Fig. 13). On the other hand, the mean bill sizes of *salvini* populations vary, and some closely resemble *desolata* while others more resemble *vittata*. The mean bill size of *desolata* is approximately 14·5 x 27·5 and *vittata* 21 x 34; the *desolata* specimens in Figure 14 are typical examples of their respective populations, and in Figure 15 *vittata* B27 represents average size. The similarity of both forms is shown in Figure 15 (B22, B26, and others). Murphy (1936) illustrated typical specimens of each, but Fleming (1941), followed by Serventy *et al.* (1971), diagrammatically illustrated their bill characters and showed a *vittata* with an abnormally wide bill compared with a *desolata* of average bill size, but with an unusually wide dertrum, which gives the impression that they are vastly different birds.

(c) ZONES OF INTERGRADATION

At all their proven breeding grounds populations of *turtur* and *crassirostris* are allopatric. The different whale-birds are also allopatric breeders except that both *belcheri* and *desolata* breed on îles Kerguelen and Despin *et al.* (1972) reported that *belcheri, desolata* and *salvini* breed on île de l'Est, Archipel Crozet.

The Intergrading Characters of Populations of Fairy Prions

The fairy prions were classified as two species mainly because of differences in the stoutness of their bills. To ascertain the comparative stoutness of the bills of different populations, a graded series of six bill dimensions was scored according to index values from 0 to 4 (Table 2). A true hybrid index could not be devised because the measurements are very small and individuals of the most different forms sometimes share characteristics, and, consequently, it is very difficult to define phenotypes. Use of wider scales of dimensions produces less differences in the mean index values of the various populations, and they would be barely distinguishable.

The measurements required for the bill stoutness index could only be taken from a rather small sample of specimens. These measurements (illustrated in Fig. 10: A32) were: (1) bill width at base, (2) the width of the maxillary unguis, (3) bill depth from the base of the nasal tubes, (4) bill depth from the point in front of the nostrils, (5) bill depth from the top of the maxillary unguis to the lower angle of the mandibular unguis, (6) the actual bill length (i.e. *not* culmen length). Pertaining to stoutness, higher index values were given for greater width and depth measurements, but lesser scores were afforded to greater bill length measurements.

The index value of each specimen equals the mean score of the six dimensions, and the mean index and per cent value of bill stoutness of populations was calculated (Table 3). Figure 18 diagrammatically illustrates geographical variation in the bills of these prions: each population is represented by a circle, which, according to its per cent value of bill stoutness, is partly black. A greater portion of black indicates populations with stouter bills.

TABLE 2

Index values according to stoutness of fairy prion bills. Specimens with bills of greater width and depth but lesser length are afforded higher index values.

Width		Depth			Bill Length	Index Value
at base (1)	of max. unguis (2)	from base of nasal tubes (3)	in front of nostrils (4)	at unguis (5)	(6)	
—10	—4	—9	—7	—7·5	20·6—	0
10·1—10·5	4·1—4·3	9·1—9·5	7·1—7·5	7·6—8	20·1—20·5	1
10·6—11	4·4—4·6	9·6—10	7·6—8	8·1—8·5	19·6—20	2
11·1—11·5	4·7—4·9	10·1—10·5	8·1—8·5	8·6—9	19·1—19·5	3
11·6—	5—	10·6—	8·6—	9·1—	—19	4

TABLE 3

The comparative bill stoutnesses of fairy prion populations.

Locality	No. of birds with index value: 0-1	1-1-2	2-1-3	3-1-4	Mean Index	Per Cent Value
turtur:						
Australia	7	1			0·66	16·5
Marion I.	2				0·71	17·75
Poor Knights Is.	2	2			1·08	27
Mangere Is.	2	4			1·27	31·75
Cook Strait Is.		2			1·41	35·25
Whero I.	1	3	1		1·43	35·75
Falkland Is.		2			1·49	37·25
Motunau I.		3	1		1·7	42·5
crassirostris:						
Heard I.		2	2		2·03	50·75
Auckland Is.		1	1		2·33	58·25
(Antipodes Is.)			1	1	2·99	74·75
Bounty Is.			2	2	3·24	81
Pyramid Rock			1	3	3·49	87·25

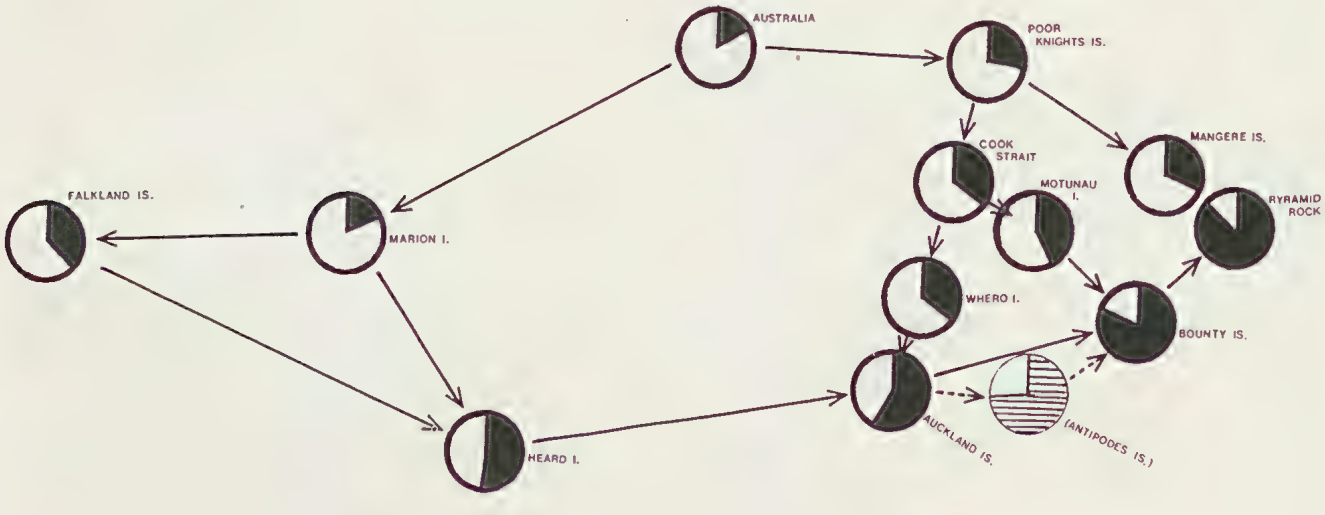

Fig. 18—Geographical variation in the bills of fairy prions. The comparative bill stoutness of each population is indicated by the percentage of black in the circle representing each. Stouter-billed forms are indicated by a greater percentage of black, and by arrows pointing from more slender-billed forms. Although the Antipodes Is. are not a confirmed breeding ground, the bill stoutness of two *crassirostris* said to be from this locality is indicated to show that they are intermediate between Auckland Is. and Bounty Is. birds.

Subjective judgments of bill stoutness compliment the index. Falkland Is. birds have neither a stout nor a slender bill (fig. 6: A3, A4) and in many respects appear to be intermediate between *turtur* and *crassirostris*. Stouter-billed birds breed on Heard I., and Auckland Is. birds seem intermediate in bill bulbosity between the birds of Heard I. and Antipodes or Bounty Is. Fleming (1939) pointed out that there is a progression towards greater bill bulbosity from birds of Antipodes Is., to Bounty Is., and to Pyramid Rock in the Chatham Group. Marion I. and southern New Zealand *turtur* are different intermediates between the stout-billed forms and slender-billed Australian and northern New Zealand *turtur*.

The distributions of *turtur* and *crassirostris* cannot be correlated with the surface water zones of the Southern Ocean as was believed by Fleming (1941), for both breed in the Subantarctic Zone (Fig. 1).

Throughout their respective ranges, *turtur* and *crassirostris* are connected by populations with intermediate characteristics, suggesting that both are heavily affected by gene-flow. This intergradation is probably indicative of adaptations to local environments rather than of hybridization. However, the Mangere Is. and Pyramid Rock populations (both in the Chatham Group) probably each stem from different parental stock; the former closely resembles New Zealand *turtur* and the latter Bounty Is. *crassirostris*. These taxa are nevertheless allopatric, and their characteristics, being mainly differences in size, are not greatly divergent from their hypothetical common ancestor (see Fig. 7).

The Intergradation of Different Whale-Birds

To some extent the differing bill characters of whale-birds can be related to latitudinal distribution. Small-billed *desolata* breeds in the Antarctic and Subantarctic Zones; intermediate *salvini* breeds on islands in the Subantarctic; and large-billed *vittata* breeds on islands close to the Subtropical Convergence. This distribution indicates that the three forms replace each other geographically, but *belcheri*, which has the smallest bill of the whale-birds, does not fit this pattern, and is known to breed only in the western Subantarctic Zone. Therefore these prions do not differ in characteristics entirely according to their latitudinal distribution or to the surface water zones.

In Figure 19 the three *desolata* population groups of the Antarctic Zone (Scotia Sea, Heard I. and Cape Denison) are diagrammatically illustrated on the same plane, and eastern Subantarctic *desolata* (Macquarie I. and Auckland Is.) are connected by a vertical line in the east to indicate their geographic position. Arrows point from Scotia Sea and Cape Denison populations to Heard I. *desolata* and then to Subantarctic Indian Ocean *salvini*, Subtropical Indian Ocean *vittata (macgillivrayi)* and *vittata* of the southern Atlantic and New Zealand regions to indicate their progressively greater bill sizes. Falkland Is. *belcheri* are shown isolated NW of Scotia Sea *desolata* and connected by an arrow to the Subantarctic Indian Ocean islands where intermediates between *belcheri* and other whale-birds breed. Figure 19 indicates that two taxa *(desolata* and

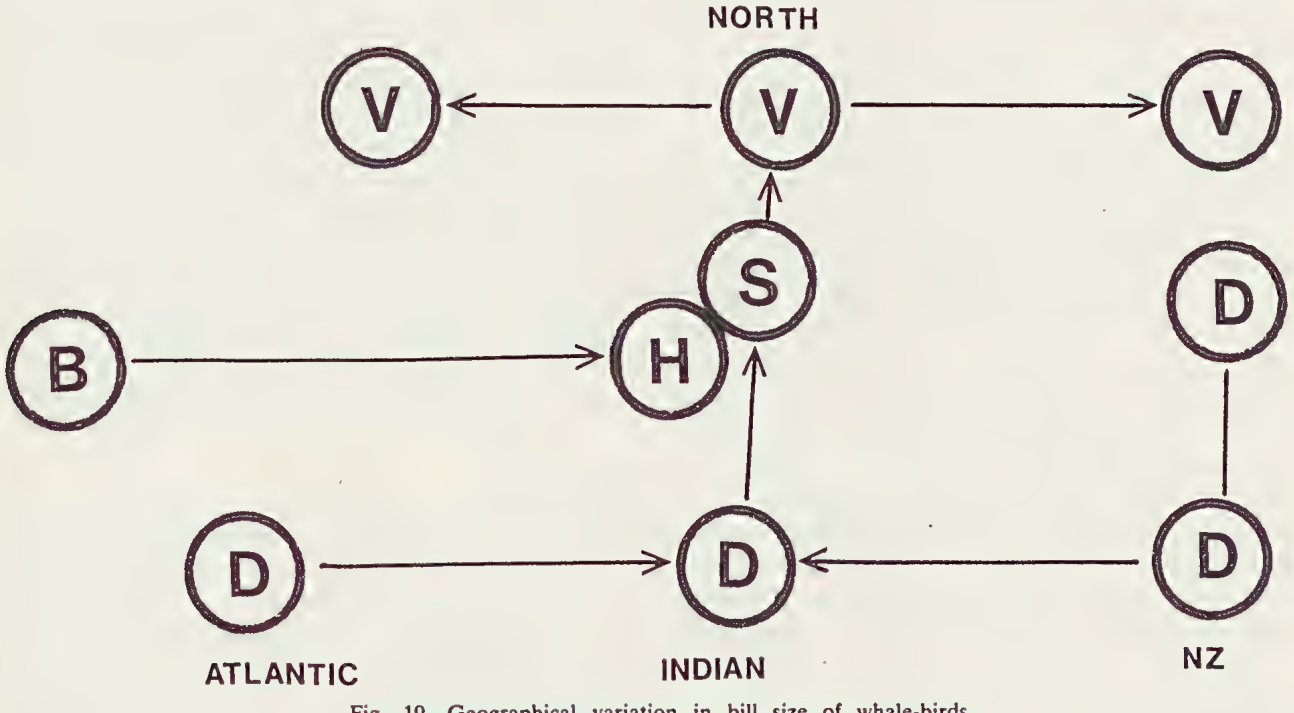

Fig. 19—Geographical variation in bill size of whale-birds. Arrows point to larger-billed forms. D=*desolata*, S=*salvini*, V=*vittata*. Arrow from B=*belcheri* points to H=hybrid *belcheri* x *desolata*—*salvini*. Intergradation of bill size occurs in the southern Indian Ocean region.

vittata) are allopatric in the southern Atlantic and New Zealand regions, but are connected by intermediate forms *(salvini)* in the southern Indian Ocean region.

The intergrading characteristics of *desolata* and *vittata* can also be demonstrated by their bill dimensions. In the southern Atlantic and New Zealand regions, where there are no intermediate *salvini* populations, the differences in their mean bill widths are 7·1 and 7·3 respectively. But in the southern Indian Ocean region where intermediate *salvini* populations also breed, the difference between *desolata* (excluding îles Kerguelen and île de l'Est forms which hybridize with *belcheri*—see below) and *vittata* in mean bill width is only 3·3. Heard I. *desolata* have a slightly larger bill than other *desolata* (Fig. 13) and île Saint-Paul *vittata* have a smaller bill than other *vittata* (Fig. 16). The *salvini* populations, having varying mean bill sizes, are probably of hybrid origin but have not themselves become a new specific entity because in their range of variability (bill width from 14·0 to 20·5) they include the characteristics of both parental phenotypes. Gene-flow through the apparent hybrid swarms to the parental populations indicates that *desolata* and *vittata* are conspecific.

Hybridization of Thin-billed and Broad-billed Whale-Birds

Differences between *belcheri* and members of the *desolata-salvini-vittata* complex indicate that parental populations of both were isolated for a prolonged period and that the intermediate forms of the southern Indian Ocean region result from hybridization.

At îles Kerguelen *belcheri* is much less numerous than *desolata* (Falla 1937) and although specimens have been taken at different localities in the archipelago, Derenne *et al.* (1974) mapped only one *belcheri* colony as compared to thirteen *desolata* colonies. The characteristics of birds from only three colonies are known, but of these one consists of birds which closely resemble *belcheri* parental phenotypes; another apparent *desolata* parental phenotypes; and a third consists of birds with intermediate characteristics (fig. 13). Also, specimens taken elsewhere in the archipelago show that the characteristics of both forms intergrade (fig. 12: B5-B13). It is therefore highly probable that many îles Kerguelen prions are hybrid *belcheri* x *desolata*. Nevertheless, because prions usually return to their natal colonies for breeding (Fleming 1941) each colony may consist of very similar birds that differ slightly from birds of other colonies. The îles Kerguelen prion assemblage probably therefore consists of locally different parental and hybrid populations.

Despin *et al.* (1972) said that on île de l'Est *salvini* are abundant and breed over most of the island wherever suitable nesting sites are available. They also reported a very small isolated colony containing both *belcheri* and *desolata*, but the characteristics of these birds appear analogous to the intergrading characters of *belcheri and desolata* of îles Kerguelen. However, the similarity in tarsus and wing lengths of these île de l'Est *belcheri* and *desolata* indicates they are more closely related to each other than to any other populations of either form. The data suggest they were only separated by bill size, and this distinction appears quite artificial. The alleged *desolata* appear to be hybrid *belcheri* x *desolata*, but they may well be hybrid *belcheri* x *salvini* because in bill, tarsus and wing dimensions they are intermediate between *belcheri* and *salvini* of the same island.

A hypothetical hybrid *belcheri* x *salvini* would probably closely resemble true *desolata*. The apparent isolation of these probable hybrids and *belcheri* in one small colony suggests they are unlikely to extensively and freely interbreed with *salvini* from outside the colony.

Cawkell and Hamilton (1961) said *belcheri* is very numerous in the Falkland Is. and is greatly increasing its numbers and colonizing new islands. This increase suggests that elsewhere *belcheri* may have encroached upon the breeding range of other whale-birds.

(d) DIFFERENCES IN BREEDING TIMES

Prions of each island population have probably developed a rather stable breeding cycle adapted to the local environment. Fleming (1941) reasoned that differences in breeding dates of the species he recognised were effective isolating mechanisms. However, similar forms breed at different times that correspond to latitude and climate. Birds breeding further south in a cooler climate usually have later egg-laying dates than those breeding in northern warmer latitudes. These facts (detailed below), and that *belcheri* and *desolata* hybridize although their parental populations usually breed at different times, suggest that differences in breeding cycles have not yet become effective isolating mechanisms.

Fairy Prions

Fleming (1941) said that *turtur* usually lay eggs in mid-October while *crassirostris*, which he recognised as of a cooler zone, lay in mid-November. But all *turtur* populations do not breed synchronously. Buddle (1941) said birds of the northern Poor Knights Is. lay eggs about 15 October, Crockett (1954) suggested the more southerly Montunau I. birds breed slightly later, and Richdale (1965) said the peak egg-laying date of a southern New Zealand

population is about 16 November. Subantarctic Marion I. *turtur* also probably lay eggs in mid-November, for van Zinderen Bakker (1971) said that: "at the end of February 1966 two nests were found both containing nearly fully fledged chicks which were ready to depart to sea." The incubation period of this species is about 56 days and the fledging period 44-55 days (Serventy *et al.* 1971). Snares Is. *turtur* also probably lay in mid-November, judging from dates on which chicks were found (see above—"Breeding Distribution), and two chicks found on eastern Sister islet in the more northerly Chatham Group, listed by Dawson (1955) as the "Chatham fulmar prion", must have come from eggs laid in October; the normal laying time of northern *turtur*. Therefore the breeding times of many *turtur* and *crassirostris* are similar.

Whale-Birds

The whale-birds also differ in breeding times according to latitude and climate. On Tristan da Cunha *vittata* usually completes egg-laying by the end of August (Elliott, 1957), whereas further south on Gough I. eggs are laid in mid-September (Swales 1965). The peak egg-laying date of southern New Zealand *vittata* is about 6 September (Richdale 1944). Subantarctic *salvini* lay about mid-November (Rand 1954) and antarctic *desolata* lay eggs throughout December (Tickell 1962). Like *salvini* sub-antarctic *belcheri* also lay their eggs mainly in mid-November (Falla 1937). Some of these prions have flexible breeding times which indicate that different forms may meet when in a similar breeding condition. On Gough I. a fresh *vittata* egg was found in mid-November (Swales 1965) and Falla (1937) found a *desolata* on îles Kerguelen (parental phenotype, form A) in a burrow with a fresh egg on 19 November. Tickell (1962) said of antarctic *desolata* that "eggs are laid throughout December, the earliest record being 5 December" and that some eggs are laid as late as January if snow blocks nesting holes.

There is little consistency in the breeding times of hybridizing populations. At îles Kerguelen *belcheri* lay eggs in November and most *desolata* lay in December (though an egg is known from mid-November), but form B of probable mixed parentage have an earlier cycle than other *desolata* (Falla 1937). Despin *et al.* (1972) said that on île de l'Est *belcheri* and *salvini* breed at the same time, but that *desolata* breeds later. However, they presumed *belcheri* has an incubation period 10 days longer than these alleged *desolata* when calculating laying dates from two *belcheri* chicks and an unspecified number of alleged *desolata* eggs. While incubation periods do vary, there is no reason to suppose the periods of these birds differ. It is also odd that they listed the dimensions of île de l'Est *belcheri* eggs, but did not mention finding any, whereas they did not give dimensions of the alleged *desolata* eggs. Accepting that they assigned the eggs to the right (doubtfully separable) adults and that their judgments of lapsed egg incubation times were correct, the data of Despin *et al.* indicate in fact that two *belcheri* chicks came from eggs laid 15 days apart, and that the alleged *desolata* eggs were laid 23 days later. While the laying dates of the last eggs are not known, it is reasonable to presume that some eggs were laid earlier than others. Therefore in this small colony there is wide variation in laying dates, a situation very similar to the different breeding times of îles Kerguelen birds. Because different breeding times do not separate forms on îles Kerguelen it is doubtful that they act as isolating mechanisms on île de l'Est. It must also be considered that the alleged *desolata* are probably hybrid and their different laying times may be the result of some selective factor that enables the parental forms to retain their own identity.

(e) FEEDING HABITS

The feeding habits of Australian *turtur* are probably similar to those of *belcheri*, but both differ in feeding behaviour from other whale-birds.

Robinson (1961) observed *turtur* diving from the surface of Port Phillip Bay, Victoria, to feed on small whitish crustacea. On surfacing they ran across the sea with wings held horizontally before alighting at another spot preparatory to diving again. I have seen *turtur* feeding in a similar manner, but off the South Australian coast have also seen them feeding in large flocks, picking from the surface while in flight, pattering with their feet and fluttering erratically over the sea. Serventy *et al.* (1971) listed the food of *turtur* as "Crustacea" and that of *crassirostris* as "Pteropods and other molluscs, amphipods, small fish", but Watson (1975) also listed "Small crustaceans" in the diet of *crassirostris* and "Small squid" in the diet of *turtur*.

Harper (1972) said *belcheri* largely feed on the amphipod *Parathemisto gaudichaudii* and less often on small cephalopods, and observed them at night "dashing helter-skelter over the water feeding voraciously on surface plankton like storm petrels . . .occasionally patting the water with the feet to obtain extra momentum". On the other hand he found that *desolata* feed mainly in the day in a manner described by Murphy (1936), who said "the birds worked along with an odd creeping motion, resting their bodies lightly upon the surface but holding the wings just above it, the feet furnishing all of the motive power." The major food of *desolata*, *salvini* and *vittata* are crustaceans, particularly the Krill *Euphausia superba* of southern waters,

although cephalopods, pteropods and small fish are also taken (Murphy 1936; Serventy *et al.* 1971; Harper 1972; Watson 1975).

IV. DISCUSSION

There is agreement that *vittata* evolved from thin-billed ancestors (Murphy 1936; Falla 1940; Fleming 1941), but Fleming (1941) also hypothesized that *crassirostris* has retained many features of the ancestor of all prions. This latter hypothesis means that thin-billed forms evolved from ancestors resembling modern *crassirostris,* which is antithetic because the phyletic lineage of thin-billed forms would probably have included transitional forms resembling modern *turtur,* yet Fleming believed that *turtur* and *crassirostris* only recently diverged from a single common ancestor. However, there is evidence indicating that the common ancestor of prions had an elongated bill with a large but narrow dertrum, like the bills of Australian and northern New Zealand *turtur.* This evidence is gained by comparing prions with close relatives.

Monotypic *Halobaena* is very closely-related to *Pachyptila.* It is also close to *Pterodroma* but differs in having a prion-like palate (Alexander *et al.* 1965). Contrary to Alexander *et al.* (1965), Harper (1978) said, when summarizing results of plasma protein studies, that it is "probable" that "*Pachyptila* and *Halobaena* are only very distantly related; the prions evolved from a small fulmarine ancestor, whereas the *Pterodroma* group gave rise to the blue petrel." Nevertheless, Harper did not have plasma samples of *Halobaena* and he aligned it with *Pterodroma* and not *Pachyptila* because the former two show "little tumescent development of the latericorns" (p.529). However, it is generally agreed that primitive prions had narrow bills and that broad-billed forms evolved later (Murphy 1936, Falla 1940, Fleming 1941), and some modern prions lack broad latericorns. Harper also compared the long nasal tubes of fulmarines to the short tubes of *Pterodroma,* but in respect of these *Pachyptila* and *Halobaena* have consistently short tubes. Although *Halobaena* has similar plumage characters (except crown and forehead) to those of prions and these may have resulted from convergence (Harper *loc. cit.*), it also differs from *Pterodroma* in lacking an entirely black bill (Cox 1976). The question of the relationships of these genera must remain open because little evidence supports the hypothesis that *Pachyptila* is more closely-related to fulmarines than to *Halobaena,* or the hypothesis that *Halobaena* is more closely-related to *Pterodroma* than to *Pachyptila.* Therefore there is little reason as yet to dispute the opinions of Alexander *et al.* (1965) that *Halobaena* is closely-related to *Pachyptila* and *Pterodroma.* The bill of the Blue Petrel *Halobaena caerulea* greatly resembles that of *belcheri* although viewed in profile its dertrum is larger and more strongly hooked, resembling some slender-billed *turtur.* Viewed dorsally the dertra of *Halobaena* and small *Pterodroma,* particularly of the subgenus *Cookilaria,* are narrow and similar to those of *turtur* and *belcheri* but unlike that of *crassirostris.* Slender-billed *turtur* and *belcheri* are the only forms of each prion group with similar bills, and the only prions which resemble in bill characteristics birds of closely-related genera.

Salient aspects of modern prion distributions also indicate that *turtur* is an ancient form. In the Australian and New Zealand region its populations are large and abundant, but in the southern Atlantic and Indian Ocean regions, where whale-birds are numerous, it is only known from a few isolated colonies. Together with the fact that *turtur* has bill characteristics like those of *belcheri* only in the Australian and northern New Zealand region (Marion I. *turtur* have thin, but short bills) where the breeding ranges of the two prion groups do not overlap, these aspects suggest ancestral *turtur* were widespread but that only remnant populations survived competition with ancestral whale-birds in the western parts of their range. In areas of overlapping range *turtur* has a stouter bill, indicating that both prion groups were able to co-exist only after ecological adaptations evolved.

It is evident that populations of the common ancestor of whale-birds became isolated. Some, the progenitors of *belcheri,* did not diverge in morphology to any great extent, but others appear to have utilised the teeming crustacea of the Southern Ocean as their major food source and through selection developed a different bill structure. These birds, having adapted to a food supply largely unexploited by other prions, successfully spread and, eventually, their populations became isolated. The northern birds developed larger bills (conforming to Allen's Rule that warm-blooded animals have greater surface areas in warm regions, and have a reduced surface area—volume ratio in cooler regions as an adaptation to prevent heat loss—Mayr 1963) and in two regions where they are not connected by zonally intermediate populations to southern smaller-billed forms they appear quite distinct. However, their different bill sizes may be purely adaptive characteristics which are not necessarily indicative of fundamental changes in genetic composition, because where intermediate forms occur the differences in nearby parental forms are less pronounced. The early isolate from common ancestral whale-bird stock, *belcheri,* presumably increased in numbers and range and, where it colonised islands already occupied by wide-billed whale-birds, interbreeding occurred.

Classification

Fundamental to a valid classification is an understanding of the relationships of the different prions, and recognition of their dynamic evolutionary trends. Previous classifications of prions have, to say the least, artificially categorised populations by doubtful morphological characteristics. The synonymy is vast and confusing. Condon (1975) listed 58 names, of which 34 were bestowed by G. M. Mathews. Hellmayr and Conover (1948) said Mathews had "within a years time, based two different names on the very same specimen in the British Museum". A major cause of this confusion is the inter- and intra-specific variation in prion bills. Beach-washed specimens far from their unknown natal home were sometimes named as distinct forms because of bill differences (Mathews 1912), but substantial collections in the Australian Museum and the South Australian Museum show complete intergradation in the characteristics previously used to distinguish species. Intermediates are numerous. Smaller samples from many breeding localities demonstrate similar inconsistencies.

The characteristics of *turtur* and *crassirostris* intergrade over a wide area, indicating conspecificity. Many island populations appear to have slightly diverged in different directions and a dimensional analysis of specimens is required to clarify geographic variation. Both forms have been subject to recent gene-flow but their respective ranges appear to be clearly demarcated in the Chatham Group although delimitations elsewhere are unclear. As an interim measure to indicate the relationships of populations, Heard I. and Auckland Is. birds are here classified as a phenotypic form that is intermediate between *crassirostris* of Pyramid Rock and the Bounty Is. (including the two specimens alleged to be from Antipodes Is.), and *turtur* of the Falkland Is., Marion I., Australia and New Zealand.

Differences in morphology and feeding habits indicate that *belcheri* is evolving on a different evolutionary line from other whale-birds. Parental populations of both are thriving and in their zone of overlap and hybridisation it is probable, at one locality, that hybrids are disadvantaged.

The other whale-birds consist of two taxa connected by intermediate populations in a wide area that contains few, if any, parental phenotypes. Because this zone of intergradation is between two regions where both taxa are clearly demarcated in allopatric breeding distributions, it is probable that intergradation occurred through hybridization. By virtue of the island distribution of these probable hybrid populations, and to illustrate clearly their relationships, they are here tentatively classified as a phenotypic form. Other than *desolata, salvini* and *vittata,* subspecific recognition of other slightly different populations within the species is arbitrary. Tickell's (1962) recognition of *banksi* and *alter* = *macquariensis* is not followed here because the characteristics of each vary over a wide area, indicative of slight geographic variation, and few individuals would be identifiable. In view of the occurrence on îles Kerguelen of both *desolata* and *desolata* x *belcheri,* the identity of the lost holotype of *desolata* may be questioned. In the absence of evidence to the contrary, I here consider the type of *desolata* to have come from the *'desolata'* phenotype colonies rather than from one of the hybrid colonies. If the type of *desolata* (Gmelin, 1789) is found to be hybrid, *banksi* Smith, 1840 should be resurrected as the name for this southern subspecies of *P. vittata.*

The following tentative classification is proffered until sufficient evidence suggesting otherwise is forthcoming. In the hope of preventing possible future misinterpretations of "possible" or "probable" breeding grounds, only *proven* breeding localities of each taxon are listed. In both subspecies and species the taxa of presumed oldest lineage are listed first. Condon (1975) listed synonyms of the scientific nomenclature used, and the English names proposed by the Royal Australasian Ornithologists Union (1978) are followed; one is of common usage and two are descriptive.

Genus **Pachyptila** Illiger, 1811.

Pachyptila turtur (Kuhl, 1820) FAIRY PRION

Pachyptila turtur turtur (Kuhl, 1820)

Breeds: Beauchene I., Falkland Group; Marion I.; islands in Bass Strait and off Tasmania; islands off New Zealand from the Snares Is. North to the Poor Knights Is.; Big and Little Mangere Is., Chatham Group.

Pachyptila turtur eatoni (Mathews, 1912)

Breeds: Heard I. and the Auckland Is.

Pachyptila turtur crassirostris (Mathews, 1912)

Breeds: Bounty Is., and Pyramid Rock of the Chatham Group.

Pachyptila belcheri (Mathews, 1912) SLENDER-BILLED PRION

Breeds: Falkland Is., île de l'Est of Archipel Crozet, and îles Kerguelen.

N.B. Interbreeds with the following species where both occupy the same islands.

Pachyptila vittata (Forster, 1777) BROAD-BILLED PRION

Pachyptila vittata desolata (Gmelin, 1789)

Breeds: S. Shetland Is., S. Orkney Is., S. Sandwich Is., S. Georgia, îles Kerguelen, Heard I., Macquarie I., Auckland Is., Scott I. and Cape Denison of Antarctica.

Pachyptila vittata salvini (Mathews, 1912)
Breeds: Marion and Prince Edward Is., and Archipel Crozet.

Pachyptila vittata vittata (Forster, 1777)
Breeds: Tristan da Cunha, Gough I., Île Saint-Paul, Île Amsterdam, Snares Is., Chatham Is. and the mainland coasts of Foveaux Strait and south-western fiords of South I., New Zealand and islets off Stewart I.

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EVOLUTIONARY SYSTEMATICS OF *XENYLLA*. XI. SPECIES FROM THE AUSTRALIAN REGION

(INSECTA: COLLEMBOLA)

by

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ABSTRACT

GAMA, M.M.da, 1979. Evolutionary systematics of *Xenylla*. XI. Species from the Australian region (Insecta: Collembola). Rec. S. Aust. Mus. 18(5): 123-129.

In some material from all states of Australia the author found twelve *Xenylla* species, one of which—*X. victoriana*, is new. In addition the chaetotaxy of *X. littoralis* from Australia and Japan was studied. The systematics and evolution of some of these taxa are considered.

INTRODUCTION

Following my studies on some *Xenylla* species from Australia, principally from South Australia (Gama 1974), Mrs. Penelope Greenslade of the South Australian Museum, Adelaide, kindly separated out for me the *Xenylla* species from 62 samples which she had assembled from all States of Australia, the Torres Strait Is., Tasmania and New Caledonia. Most of the material had been collected by Mrs. Greenslade herself.

The material contained 12 species, of which one is new, but the most interesting find is, in my opinion, that of *X. littoralis*, which also lives in the littoral zone in Japan.

Mrs. P. Greenslade also sent me the H. Womersley collection of examples of this genus which has been very useful for my study, especially when considering *X. littoralis*.

The material is deposited in the Institutions cited below, whose names have been abbreviated in the text as follows:—

SAM—	South Australian Museum, Adelaide
ANIC—	National Insect Collection, c/o C.S.I.R.O., Division of Entomology, Canberra
MG—	Muséum d'Histoire naturelle de Genève
MC—	Museu Zoológico da Universidade de Coimbra

SYSTEMATICS AND EVOLUTION OF THE SPECIES

1. *Xenylla welchi* Folsom, 1916

Xenylla welchi Folsom, 1916, p. 497.

Material examined—Launceston, Tasmania, in horse manure, garden, very numerous specimens, 9.v.1977. Some specimens in alcohol (SAM); some specimens, in alcohol (ANIC) and some specimens, in alcohol (MC).

2. *Xenylla littoralis* Womersley, 1934

Xenylla littoralis Womersley, 1934, p. 56.

Description—Body length, 1.2-2.1 mm. Blue. Cutaneous granules coarse and third pleurite possessing a lateral conical projection.

Chaetotaxy consisting of supernumerary setae, sometimes very numerous, principally in those specimens with a long body, and often very irregular. Therefore I found it very difficult to determine the chaetotaxic formula of this species.

On the drawing of dorsal chaetotaxy (fig. 1), the dotted line setae represent the most frequent supernumerary setae, but most specimens have many more. Moreover in this species one can distinguish a differentiation into macrochaetae and microchaetae, which is unusual in the genus *Xenylla*.

Dorsal chaetotaxy (fig. 1):

Head: all setae present; L_1 longer than L_3 (character f).

Th.II-III: all setae present and central setae arranged in three rows; there are 2 S.s. on each side, one of which in position P_4.

Abd.I-III: S.s.=P_6; p_5 present.

Abd. IV: S.s.=P_5; p_3 absent (character n). I am not sure whether a_3 is, or is not, present.

Abd. V: all setae present.

Ventral chaetotaxy:

Head: I think that one may consider that all setae are present, although p_1 or m_3 are absent on some specimens (fig. 1 in Gama 1969: 4).

Th.II-III: without setae (character t).

Abd. II: p_1 and p_2 absent (character v) and p_6 also (character w).

Abd. III: without medial setae nor median seta.

Abd. IV: all setae present.

Antenna IV with four sensillae, of which the two most external of the three dorso-external are very long, the ratio between the length of the other two sensillae and the length of these ones being more or less 3:4.

5+5 eyes.

Unguis with inner tooth. Tibiotarsus with two dorsal tenent hairs. Tenaculum with 2+2 barbs. Mucro very long, distinctly separated from dens, which has two setae, tapering to a fine point and

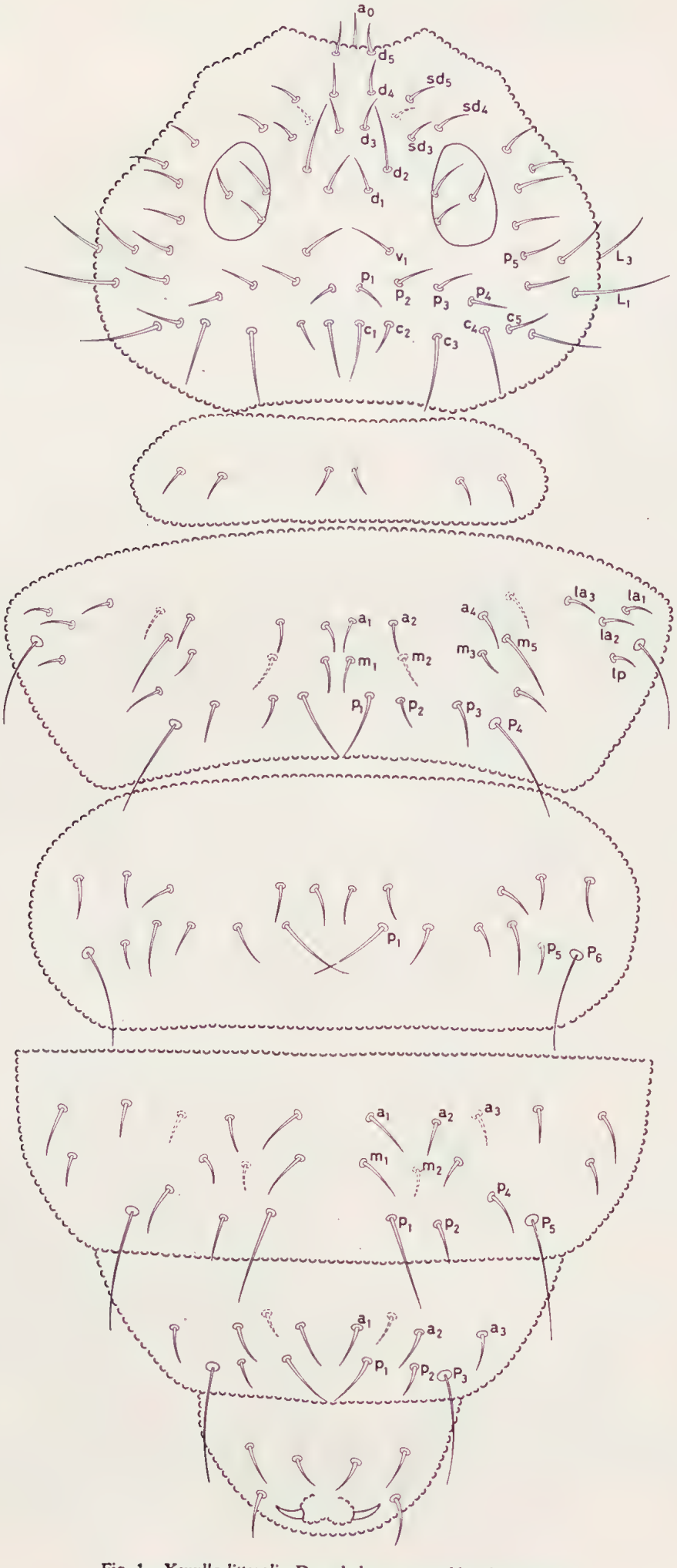

Fig. 1—*Xenylla littoralis*. Dorsal chaetotaxy of head, th. I-II and abd. I, IV, V, VI.

possessing one inner narrow lamella. Mucro more or less equal in length to dens, a little longer or a little shorter (fig. 41-E in Womersley 1939: 93).

Anal spines and papillae very well developed.

Systematics and evolution—When Prof. Yosii, in 1972, sent me one sample of *Xenylla* from Japan (see material examined) he thought that it perhaps belonged to *X. littoralis*, but added that Australia was quite a distance from Japan!

Several times I looked again at this halophilous species, without arriving at any conclusion.

When only some months ago, I had the chance to compare this material and the material cited below with the Womersley collection, and was able to confirm that the Japanese species is identical with *X. littoralis* from Australia, not only in the adaptative characters but also in the chaetotaxic characters (fig. 1).

The examination of three paratypes of *X. arenosa* Uchida and Tamura, 1967, a Japanese species which also lives in the seashore, reveals that it can be separated from *X. littoralis* by some fundamental nonadaptative characters, namely the character b (cephalic setae p_1p_1 absent) although the central setae on th. II-III are arranged in three rows (absence of characters h_1 and h_2) as in *X. littoralis*.

I think that the principal adaptative characters by which the Womersley species is separated from *X. arenosa* are that the former species has two tenent hairs on its tibiotarsus while the latter has only one; furthermore *X. littoralis* possesses anal spines but *X. arenosa* does not; finally *X. littoralis* has a less tapered mucro than *X. arenosa*.

Material examined—South Australia: Yorke Peninsula, Jolly's Beach, 21 mi. E. Sleaford Bay, under stones between tides, 7 specimens, leg. P. Greenslade, 3.ix.1975—1 specimen, on slide (SAM); 1 specimen, on slide (ANIC); 1 specimen, on slide (MG); 4 specimens, on slide (MC); Yorke Peninsula, Royston Head, on beach between tides, 8 specimens, leg. P. Greenslade, 27.i.1976—2 specimens, in alcohol (SAM); 2 specimens, in alcohol (ANIC); 2 specimens, in alcohol (MG); 2 specimens, in alcohol (MC); Christies Beach, 4 specimens, 25.i.1932 (identified by Womersley). Western Australia: Rottnest Island, 1 cotype, 31.i.1931 (identified by Womersley); Marino Rocks, 2 specimens, 25. XII. 1939 (identified by Womersley). Japan: Cape Tachimachi, near Hakodate, Hokkaido, among the debris thrown on the sea shore, 9 specimens, leg. R. Yosii, 5.viii.1971. These specimens are on a slide and in alcohol (MC).

3. *Xenylla thibaudi thibaudi* Massoud, 1965
Xenylla thibaudi Massoud, 1965, p. 374.

Observations—This is the first time that *X. thibaudi thibaudi* has been found in Australia, but it has been already found in New Guinea, the Solomon Islands and the Bismarck Archipelago.

Material examined—Queensland: Cooloola, rain forest litter, 7 specimens, leg. P. Greenslade, 23.ii.1977—in alcohol (MC); Idem, 3 ad. + 3 juv., 16.ii.1977—in alcohol (ANIC); Cooloola, rain forest pitfalls, 2 specimens, leg. P. Greenslade, ii.1977—in alcohol (MG); Cooloola, Warrawonga pitfalls, 2 specimens, leg. P. Greenslade, ii.1977—in alcohol (SAM); Cooloola, Warrawonga leaf litter, 8 specimens, leg. P. Greenslade, 16.ii.1977—in alcohol (MG); Idem, 12 specimens, 23.ii.1977—in alcohol (ANIC); Idem, 40 specimens, 29.iii.1977—in alcohol (MC); Cooloola, Birwillah litter, 12 specimens, leg. P. Greenslade, 16.ii.1977—in alcohol (SAM). New Caledonia: Metzdorf Valley, litter, 5 juv., leg. Gross, 5.i.1966.—in alcohol (MC).

4. *Xenylla yucatana* Mills, 1938
Xenylla yucatana Mills, 1938, p. 183.

Material examined—Torres Strait Islands: Murray Is., litter from vine, bamboo forest, about twenty specimens, leg. Cameron, 17.vii1974—in alcohol (MC); Murray Is., leaf litter, about fifteen specimens, leg. Cameron, 17.vii.1974—in alcohol (SAM).

5. *Xenylla womersleyi* Gama, 1974
Xenylla womersleyi Gama, 1974, p. 81.
Material examined—South Australia: Nuyts Archipelago, Maselon Island, litter from *Westringia* sp., 5 specimens in poor condition, leg. P. Greenslade, 17.i.1977—in alcohol (MC).

6. *Xenylla australiensis australiensis* Gama, 1974
Xenylla australiensis Gama, 1974, p.75.

Synonym—*Xenylla mucronata* Womersley, 1939 *non* Axelson, 1903.

Systematics—The Womersley collection includes other specimens, mounted in slides, named as *X. mucronata*, coming from the You Yang Mountains, Wartook, and also Kenwick (see Womersley 1939: 92).

However, only the specimens cited below could be studied in this work, because the other specimens are not in good condition.

Material examined—Western Australia: Ragged Mountain, 70 mi S Balladonia, near Israelite Bay, litter under *Petrophile* sp, 1 specimen, leg. P. Greenslade, 24.v.1977—in alcohol (SAM).

Victoria: Coranderrk Reserve, Healesville, about fifteen specimens, 27.i.1976—in alcohol (ANIC); Beaufort, Boxer Cutting, in grass, 1 specimen, leg.

P. Greenslade, 12.vi.1975—in alcohol (MG); You Yang Mountains, forest Reserve, from log, 1 specimen, leg. P. Greenslade, 9.vi.1975—in alcohol (MC); You Yang Mountains, 2 specimens, 23.ix.1931 (identified by Womersley as *X. mucronata*); Fish Falls, Wartook, 3 specimens, 30. XII. 1939 (identified by Womersley as *X. mucronata).*

South Australia: Innes National Park, Yorke Peninsula, litter, 35 specimens, leg. P. Greenslade, 2.ii.1974—in alcohol (SAM); Yorke Peninsula, south central, mallee litter, 15 specimens, leg. P. Greenslade, 2.ii.1974—in alcohol (MG); 7 km NW Morgan, *Casuarina* litter, 1 juv., leg. P. Greenslade, 17.xii.1976—in alcohol (ANIC); 7 km NW Morgan, pitfalls, 22 specimens, leg. P. Greenslade, 15-17.xii.1976—in alcohol (MC); near Loxton, mallee leaf litter, 2 specimens, leg. P. Greenslade, 25.ix.1974—in alcohol (SAM); Nuyts Archipelago, Maselon Island, litter under bush, 1 specimen, leg. P. Greenslade, 17.i.1977—in alcohol (ANIC); Belair, 9 specimens, leg. P. Greenslade, 28 iv.1971—in alcohol (MG); Coorong, Coolatoo, disturbance pitfalls, clay pan, in grass, 10 specimens, leg. P. Greenslade, 13.x.1975—in alcohol (MC); Coorong, Coolatoo, disturbance pitfalls, clay pan, in bushes, 6 specimens, leg. P. Greenslade, 28.ix.-13.x.1975—in alcohol (SAM); Mt. Bold, Finniss River, rotten log, about thirty juv., leg. P. Greenslade, 4.v.1975—in alcohol (ANIC); Glenelg River Reserve, *Eucalyptus* leaf litter, 12 juv., leg. P. Greenslade, 18.v.1975—in alcohol (MG); 12 km N of Mt. Gambier, needles under *Pinus radiata* planted 1929, 3 juv., leg. P. Greenslade, 19.v.1975—in alcohol (SAM).

7. *Xenylla greensladeae* Gama, 1974
Xenylla greensladeae Gama, 1974, p. 72.

Systematics—Among the Womersley material there are 4 specimens, on slides, labelled as *X. prisca* n.sp., which as far as I know, has never been described.

I have been able to study two of these specimens which were found to be *X. greensladeae.*

Material examined—Queensland: 15 mi E Killarney, rain forest near Queen Mary Falls, leaf litter, 5 specimens, leg. P. Greenslade, 16.v.1974—in alcohol (SAM); Emu Creek, 20 mi E Warwick, leaf litter, about fifty specimens, leg. P. Greenslade, 14.v.1974—in alcohol (ANIC). Western Australia: Ashburton River, stony flood plain, 5 specimens, leg. P. Greenslade, 22.vi.1975—in alcohol (MG). Australian Capital Territory: Brindabella Range nr. Picadilly Circus, *Eucalyptus* forest leaf letter, numerous specimens, leg. P. Greenslade, 26.vii.1972—in alcohol (MC). New South Wales: Dorrigo Run, pitfalls, 1 specimen, leg. Weir, i.1974—in alcohol (SAM). South Australia: Yorke Peninsula, Innes National Park, tall mallee, 9 specimens, leg. P. Greenslade, 14.x.1974—in alcohol (ANIC); Ferries-McDonald Reserve, 3 specimens, leg. E. G. Matthews, 13.x.1977—in alcohol (MG); Belair, in moss, 1 specimen (identified by Womersley as X. *prisca* n.sp.) 26.ix.1943; 7 km NW Morgan, *Casuarina* litter, 4 specimens, leg. P. Greenslade, 17.xii.1976—in alcohol (MC); Idem, 1 juv.—in alcohol (ANIC); Morgan, soil samples, 2 specimens, leg. Butler, 1974—in alcohol (SAM); 7 km NW Morgan, pitfalls, 12 specimens, leg. P. Greenslade, 15-17.xii. 1976—in alcohol (MC); Morgan, under mallee, 35 specimens, leg. Hutson, x.1974—in alcohol (SAM); Coorong, Coolatoo, disturbance traps, clay pan, in grass, 5 specimens, leg. P. Greenslade, 13.x.1975—in alcohol (MC); Coorong, Banff Transect, 35 specimens, leg. P. Greenslade, x.1975—in alcohol (MG), Muston, (Kangaroo Island), in moss, 1 specimen (identified by Womersley as X. *prisca* n.sp.), 23.viii.1943. Victoria: Tarra Falls Valley, in grass, 1 specimen, leg. P. Greenslade, 11.vi.1975—in alcohol (ANIC).

8. *Xenylla maritima* Tullberg, 1869
Xenylla maritima Tullberg, 1869, p.11.

Material examined—South Australia: 75 mi N Mt. Gambier, *Acacia/Casuarina* litter, SAM 325, 16 specimens in poor condition, leg. P. Greenslade, 19.v.1975—in alcohol (SAM); Kiutpo Forest, on dead *Pinus radiata* branches, 10 specimens, leg. P. Greenslade, 20.x.1974—in alcohol (ANIC); Glen Osmond, 3 specimens, iii.1935 (identified by Womersley). Western Australia: Perth, 1 specimen, 23.v.1931 (identified by Womersley). Victoria: Studley Park, 1 specimen, viii.1931 (identified by Womersley).

9. *Xenylla victoriana* n.sp.

Holotype and Paratypes: Victoria—Otway Ranges, fern forest litter, 45 paratypes, leg. P. Greenslade, 8.vi.1975. Holotype, on slide (SAM); 5 paratypes, on slide (MG); 7 paratypes, on slide, and 32 paratypes, in alcohol (MC); Erskin River, *Eucalyptus* woodland, litter and logs, 20 paratypes, leg. P. Greenslade, 8.vi.1975, 16 paratypes, in alcohol (SAM) and 4 paratypes, on slide (MC); Toorangi State Forest, litter and logs, 4 paratypes, leg. P. Greenslade, 10.vi.1975—in alcohol (ANIC); Tara Valley Reserve, falls leaf litter, 3 paratypes, leg. P. Greenslade, 11.vi.1975—in alcohol (MG); Tarra Falls, Wall Valley, in grass, 1 paratype, leg. P. Greenslade, 11.vi.1975—on slide (ANIC).

Description

Body length 0·62-0·92 mm. Blue. Cutaneous granules fine. Dorsal chaetotaxy revealing the following characters:

Head: p_1 is absent (character b); L_1 longer than L_3 (character f).

Th.II-III: all setae present, central setae arranged in five rows (characters h_1 and h_2) and with 2 S.s. on each side, one of each in position P_4.

Abd. I-III: S.s.=P_6; p_5 present.

Abd. IV: S.s.=P_5; a_3 present.

Abd. V: S.s.=P_3; a_2 absent (character q).

The characters of ventral chaetotaxy are as follows:

Head: all setae present.

Th. II-III: one seta on each side.

Abd. II: two medial setae.

Abd. III: without medial setae nor median seta.

Abd. IV: m_1 is absent (character a_4); m_2 is absent (character a_5)—This is the first species of *Xenylla* in which I have found character a_5.

Antenna IV with four cylindrical similar sensillae.

5+5 eyes.

Unguis without visible inner tooth. Tibiotarsus with two dorsal tenent hairs. Tenaculum with 3+3 barbs. Mucro with curved apex, possessing an inner lamella and separated from the dens, which has two setae (fig. 2). Length of mucro about one half the length of dens; mucro shorter than claw, the ratio between these two structures is between 3:5 and 3:4.

Anal spines on anal papillae with usual conformation.

Fig. 2—*X. victoriana* n.sp. Mucrodens in profile.

Systematics and evolution—The new species is genealogically very near to the group *maritima*, *brevisimilis* and *uniseta*, being distinguished essentially from these species by the presence of a_3 on tergite abd. IV and by the absence of m_2 on sternite abd. IV (character a_5—see phylogenetic tree—Fig. 34 in Gama 1969). Moreover, it is the only species I know in which this seta is absent.

X. victoriana n.sp. is further separated from the group *maritima* by the structure of mucrodens, mucro being separated from the dens in the new species, while in the species of this group mucro and dens are fused. Thus, it seems that *X. victoriana* n.sp. is anagenetically more primitive than the species of group *maritima*.

10. *Xenylla grisea* Axelson, 1900
Xenylla grisea Axelson, 1900, p. 108.

Material examined—Queensland: Emu Creek, 20 km E Warwick, rotten log, 3 specimens, leg. P. Greenslade, 14.v.1974—in alcohol (MC). South Australia: Adelaide, 4 specimens, v.1933 (identified by Womersley as *X. maritima*).

11. *Xenylla stachi wolffi* Gama, 1967
Xenylla stachi wolffi Gama, 1967, p. 15.

Observations—This subspecies is found in the Solomon Islands and in the New Hebrides. This is the first time it has been found in Australia.

Material examined—Queensland: Cooloola, rain forest litter, 2 specimens, leg. P. Greenslade, 23.ii.1977—in alcohol (MC); Cooloola, Warrawonga pitfalls, 1 juv., leg. P. Greenslade, ii.1977—in alcohol (SAM); Cooloola, Warrawonga litter, 1 specimen, leg. P. Greenslade, 29.iii.1977—in alcohol (MC); Cooloola, Chalambar pitfalls, 2 specimens, leg. P. Greenslade, ii.1977—in alcohol (MC); Cooloola, Chalambar litter, about thirty specimens, leg. P. Greenslade, 23.ii.1977—in alcohol (ANIC); Cooloola, Birwillah litter, 2 specimens, leg. P. Greenslade, 16.ii.1977—in alcohol (SAM); Cooloola, Pertaringa litter, about fifteen specimens, leg. P. Greenslade, 23.ii.1977—in alcohol (MG); Idem, about thirty specimens, 29.iii.1977, 23 specimens, in alcohol (SAM); 7 specimens, on slide (MC). Northern Territory: Alice Springs, Kunoth Paddock, hills litter, 2 specimens, leg. P. Greenslade, 17.ii.1975—on slide (MC). Torres Strait Islands: Murray Is., litter from vine, bamboo forest, about twenty specimens, leg. Cameron, 17.vii.1974, 8 specimens, on slide and the other specimens, in alcohol (MC).

12. *Xenylla* cf. *obscura* Imms, 1912
Xenylla obscura Imms, 1912, p. 84.

Systematics and evolution—The populations cited below from Australia and New Caledonia are

distinguished from the populations of *X. obscura* from Sikkim, Nepal and India (for a redescription see Gama 1969: 43-46) in the following features:—

1. The tip of the mucro is wider than on the drawing represented in fig. 28.

2. The cephalic setae L_1 and L_3 are more or less similar in length (absence of character f).

3. The cephalic seta a_o is present in some populations, but is absent in others, although within a population some variability of this character, a, may be observed.

4. Setae are in general blunt and not sharp as in the other populations of *X. obscura* which I have previously studied (Gama 1969 and 1971).

These populations that present the character, a, could possibly be considered as *X. hawaiiensis* Gama, 1969, because they are placed in the same cladogenetic level as this species (fig. 34 in Gama 1969). However, in typical specimens of the species from the Hawaii Islands the mucro is different in form (fig. 30: 51 in Gama 1969) from the mucro found in populations from Australian regions.

In 1971 (Gama 1971: 152-153) I verified, after studying some populations of *X. obscura* from Nepal, that "a greater length of the body and a greater development of anal spines seems to be correlated with the absence of a_3 on abd. IV and the greater length of L_1 in comparison with L_3. A similar correlation appears to occur between a shorter body and a lesser development of anal spines and the presence of a_3 on abd. IV and the near similarity of length of L_1 and L_3". (The above is English rendering of the original French).

However, these populations from Australia and New Caledonia do not have the seta a_3 on tergite abd. IV and the anal spines are relatively poorly developed. In body length, specimens from New Caledonia are very long whilst those from Australia are relatively short.

I have also recently examined further specimens from Nepal which Prof. Cassagnau has kindly sent me. In the four populations of *X. obscura* that I have studied, the mucro presents the characteristic form of the species, the setae are sharp, L_1 is longer than L_3 (character f), the cephalic seta a_0 is present (absence of character a), and the seta a_3 on tergite abd. IV is absent. Anal spines are only well developed in sample n^0 65.

Material examined—Queensland: Cooloola, Kabali East litter, pitfall traps, 2 specimens, leg. P. Greenslade, ii.1977—on slide (MC); Cooloola, Chalambar pitfalls, 1 specimen, leg. P. Greenslade, ii.1977—in alcohol (MC). Northern Territory: Alice Springs, Kunoth Paddock, ungroved Mulga litter, 2 ad. + 4 juv., leg. P. Greenslade, 7.ii.1975—in alcohol (ANIC); Idem, about fifty specimens, 15.ii.1975—in alcohol (SAM); Idem, 5 specimens, 15.ii.1975—in alcohol (MG); Alice Springs, Kunoth Paddock, grove Mulga litter, 8 specimens, leg. P. Greenslade, 15.ii.1975—on slide (MC); Alice Springs, Kunoth Paddock, hills litter, numerous specimens, leg. P. Greenslade, x.1974—on slides and in alcohol (MC); Idem, 40 specimens, leg. P. Greenslade, 17.ii. 1975, 34 specimens, in alcohol (ANIC), 6 specimens, on slide (MC). South Australia: Monarto South, Ferries-McDonald Reserve, in *Lepidosperma,* 15 specimens, leg. P. Greenslade, 2.x.1977—in alcohol (MG); near Loxton, mallee leaf litter, 25 specimens, leg. P. Greenslade, 25.ix.1974—in alcohol (SAM). New Caledonia: Île Nou, on the surface of a puddle of water, very numerous specimens, leg. G. Fabres, 28.xii.1977. sent by Prof. P. Cassagnau—on slide and in alcohol (MC).

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I also thank sincerely Prof. H. Uchida, Prof. S. Chiba and Dr. H. Tamura, who kindly provided some types of *X. arenosa* Uchida and Tamura, 1967, the study of which led me to conclude that this species from the Japanese littoral is not *X. littoralis.*

Finally I am particularly grateful to Mrs. P. Greenslade for giving me the opportunity to get to know the Australian *Xenylla* species.

I should like to thank Dr. M. Tully for help in the translation of this article.

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MACROPODID SKELETONS, INCLUDING: *SIMOSTHENURUS* TEDFORD, FROM AN UNUSUAL "DROWNED CAVE" DEPOSIT

IN THE SOUTH EAST OF SOUTH AUSTRALIA

by

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ABSTRACT

PLEDGE, N. S. 1980. Macropodid skeletons, including *Simosthenurus* Tedford, from a unusual "drowned cave" deposit in the South East of South Australia. *Rec. S. Aust. Mus.* 18(6): 131-141.

A drowned cave in the South East of South Australia has yielded exceptionally well-preserved vertebrate fossils, particularly of the Pleistocene macropodid *Simosthenurus* Tedford, to scuba divers. Three distinct groups of *Simosthenurus* have been recognised, including *S. gilli* (Merrilees). One (Species II) may be referable to *S. orientalis* (Tedford) while the third is a new species. Post-cranial remains associated with some skulls offer, at last, definite knowledge about the anatomy of these extinct kangaroos.

The geometry of the cave is described briefly and supports an hypothesis about the accumulation of some of the bones. It is proposed that in drought periods during the latter stages of the last glacial phase, when caves were the only local source of free water, animals entered this cave to drink and some, weakened or over-extended, fell into the underground pool and could not get out. Their carcasses sank to the bottom to leave near-complete skeletons that were protected by the post-Glacial rising groundwater.

INTRODUCTION

In 1964, scuba diver G. McKenzie passed to Mr. F. W. Aslin a small quantity of bones he had collected in a drowned cave 24 km from Mt Gambier in the South East of South Australia. The bones were subsequently examined by Dr. B. Daily, who confirmed Aslin's identification of possum bones and a palate of the extinct macropodid *Sthenurus (s.l.)*. The importance of the site was therefore apparent, and Aslin undertook to coordinate activities in the cave so that any future finds would be brought to the attention of the South Australian Museum.

This paper describes the cave site and contents in general terms and presents a possible mode of accumulation.

In 1965, some more bones were collected and examined by Daily who recognised kangaroo (*Macropus* sp.) and pig (*Sus*) remains. This material had apparently been found near the entrance on the talus cone where rubbish had been dumped.

The next finds were made in January, 1968, by divers B. Brawley and G. McKenzie. Six sets of skulls and jaws as well as other elements of *Sthenurus* were collected in three dives, most bones being in excellent condition. The divers reported they had located "a veritable graveyard", with the bones "laid out in a semi-articulated state". The bones occurred in little groups, each apparently representing a single animal. Aslin quickly sought advice from Daily on the best way of retrieving the fragile bones. In February, brief mention of the fossil deposit was made in an article in the local newspaper ("South-East has Tourist Attraction Underground": *The Border Watch*, Tuesday, 27 February, 1968).

A further diving expedition in November, 1968 yielded several more jaws and partial skulls, and it was noticeable that cranial material was becoming less obvious.

The next expedition was in January, 1969 with Brian Brawley diving again. Only eight dives were possible in the two days available, but a considerable quantity of bone, mainly post-cranial, was retrieved, including several short sequences of articulated vertebrae in partial skeletons of *Macropus* and *Sthenurus*.

In May, 1968, Daily encountered a specimen from the locality in the Australian Museum, Sydney, where it had been taken unceremoniously by some divers, whose account of their trip later appeared in

a somewhat sensationalised article in *Pix* (15 February, 1969) under the title "In Deep, Blue Water—Kangaroos Who Lived 12 000 Years Ago!" The sinkhole named ("The Pines") is not the same as the subject of this paper, but many of the features mentioned are suggestive of it, and the inset photograph was, according to Brawley, taken in the fossil cave. In a subsequent issue (*Pix*, 22 March, 1969) Dr. Alex Ritchie of the Australian Museum made a plea to divers not to disturb the fossil remains.

A final collecting expedition took place in June, 1974, to salvage any remaining obvious fossils, following evidence that unauthorised divers had been active in the cave, and would be returning. Again, Brawley did the underwater work but had trouble in finding much of significance apart from some jaws of *Simosthenurus gilli*. A quantity of scattered post-cranial material was also recovered before the water silted up to the extent that nothing could be seen.

METHODS

The very situation of the fossils caused special methods to be devised for their collection, and for plotting their relative positions.

As the fossils occurred in a flooded cave, at depths as much as 15 m, and in total darkness, special arrangements had to be made. Initially, two divers operated together on the "buddy system". Later, a diver worked alone, connected to the surface by a safety line which doubled as a communication system by way of certain signals.

Bones were exceedingly delicate and soft when found and were carefully transferred underwater into a neutral buoyancy basket lined with cotton-wool for their removal to the surface, and a shiny tag put in their place. The specimens were carefully washed to remove remnants of silt and clay, dried slowly, then treated with a dilute solution of "Glypolin" in acetone, applied several times, to harden the bone. Later collections were treated with "Bedacryl" in methyl-ethyl ketone.

Determining true relative positions of the bone assemblages proved difficult. The positions of the first finds were not noted but were indicated by tags placed by divers on a later expedition, working from memory. A grid reference system of surveying was initially considered for fixing the position of fossils, but was decided against because of the uneven topography of the rock pile. Instead, the safety line was employed as a survey instrument to determine specimen positions. At each point where the diver stopped for several minutes to pick up specimens, a tag was attached at the surface end of the line, level with a fixed datum point. At the same time, a compass reading was taken on the bearing of the line. When the rope was hauled in at the end of a dive, the distance indicated by the tag was measured. This system gave only marginal accuracy, as it could not quantify the variations in slope, nor the detours the diver might take on his descent. More accurate on a smaller scale were the sketches and notes made underwater by the diver, but again distances and directions were only estimates. It was found that determinations made on the same points varied considerably on different occasions, and correlation was exceedingly difficult. Shiny metal tags were left at each collecting point by the divers, on their second and subsequent expeditions. However, in between trips, other unauthorised but tidy-minded divers removed most of them, and it was subsequently found that the collectors' memories were not sufficient to relocate these points. Consequently, the collecting sites marked in Figure 1 are mostly only tentative.

Another major problem was that of rapidly increasing turbidity of the water, caused by the divers' movements near the bottom stirring up fine silt. It was found that two dives a day for two days were all that was feasible, and that the water then took several days to clear. In fact, a 30 minute dive was the longest possible at any time, and this duration rapidly diminished over a two-day period as remnant turbidity built up.

It is likely that many bones that are missing from the skeletal assemblages have slipped down between rocks on the slope. However, search for them was not attempted because of the twin-problems of nonvisibility and safety.

Tooth notation is that now advocated by Archer (1978) based on embryological evidence for three premolars and five molars, the first of which is replaced by P3.

OBSERVATIONS

The Cave Deposit

The South East province of South Australia is a vast limestone shelf of Oligo-Miocene age, capped by superficial Quaternary calcarenites (Bridgewater Formation) in the form of stranded beach ridges (Boutakoff 1963). Extensive cave development occurs, and centres mainly on two areas: Naracoorte and Mt Gambier (See Marker, 1975). In the former, the caves are mostly dry or with only minor pools of standing water. They tend to be labyrinthine, following joint-controlled weaknesses linking larger collapse chambers. In the Mt Gambier area, many caves have standing water and quite a number can be said to be "Drowned" following the post-glacial rise in sea level and water table. Many are designated as sink-holes, i.e. large flooded chambers breaching

the land surface in small apical openings (e.g. The Shaft), while others are typical cenotes (e.g. Little Blue Lake). Cave formation may have occurred as long ago as the late Miocene (Moriarty, pers. comm.) following regional regression of the sea, with later rejuvenation during the Pleistocene.

I consider the subject of this paper to be a drowned cave rather than a sink-hole. The fossil cave is essentially a large elongate chamber enlarged by roof collapse, in which the collapse talus cone has penetrated the breached ceiling, and full of water to within 4m of the land surface outside. The entrance doline is roughly oval, about 12m x 20m, aligned on a NW-SE axis. Emergent rocks occupy the floor but are surrounded on nearly all sides by visible water with free access limited to the south-eastern quadrant. Mr Aslin has kept records of the water table, which has fluctuated by less than 1m between winter and summer but as much as 1·8m over several years, as the result of rainfall variations. At the low water level, part of the ceiling of the cave is exposed, for a distance of about 12m. A plan and longitudinal section of the cave, as compiled from divers' notes are shown in Figure 1. There is an apparent step-like profile of the floor which may have important implications regarding the mode of accumulation of the fossils.

While bones were scattered over the upper floor of the cave, apparently derived by surface movement from the apical talus cone, the immediately obvious feature, seen by the first divers in the far recesses of the cave, were the discrete piles of bones, each of which appeared to represent a single individual.

The Faunal Assemblage

(1) Aves

Numerous bones, mainly wing bones, indicate the presence of small birds, but have not yet been studied.

(2) Marsupialia

Dasyurus maculatus (P17254)—A well preserved skull represents this taxon, undistinguishable from the modern species. Area 3.

Thylacinus cynocephalus (P17257)—A fragment of mandible with canine, premolars and first molar is referable to this extinct species. Between Areas ③ and ⑦.

Trichosurus vulpeculus is represented by a mandible. This may be a more recent addition, as fossil deposits in dry caves in the region seem to be devoid of *Trichosurus* while it is abundant in modern accumulations. Area ⑧.

Vombatus ursinus is represented by a well-preserved skull and jaws. It is possibly a more recent addition to the assemblage and its exact position is unknown.

Macropus cf. giganteus—The grey kangaroo is represented by several specimens including an immature skull and jaws (P17256), a mature skull and jaws (P17457) with partial skeleton from area ①, another partial skeleton (P17523) with a jaw (P17522) but no skull from area ⑧, footbones (P18291) from area Ⓐ. Tibiae and footbones from between areas ③ and ⑦, a partial skeleton (P17518) from area 5 (no skull or jaws).

M. rufogriseus is represented by a skull (P17255) and isolated bones and skull fragments.

Sthenurinae

In his monograph in this family, Tedford (1966) erected a new subgenus *(Simosthenurus)* for those species of *Sthenurus* having particularly brachycephalic skulls. He also cited a marked difference of elevation between palatal and basicranial planes. However, since a skull of the dolichocephalic *Sthenurus (Sthenurus)* cf. *atlas* from Naracoorte (Henschkes Fossil Cave) also shows this feature, while *S. gilli* does not, it is felt that the character may be more of specific importance than generic. I have no hesitation, in view of the excellent material from this cave, in raising *Simosthenurus* to full generic rank, and including *S. gilli* in it.

Inspection reveals three distinct species of *Simosthenurus* present in this deposit, of which only one seems to be described:

Group 1 Simosthenurus gilli: Specimens P17248 (skull and jaws), P17265 (left maxilla), P18326 (ankylosed jaws). These are closely similar to the Haystall Cave (Naracoorte) specimens referred by Merrilees (1965) to this taxon. See Table 1; Figure 2A.

Group 2 Simosthenurus Species I: Specimens P17246 (skull and jaws), P17247 (skull and jaws), P17471 (partial skull lacking cranium), P17252 (left and right jaws), P17263 (right and half of left ankylosed jaws). (Table 2 and Figure 2B). The teeth of this taxon are superficially similar to *S. gilli*; molars have the same width, but are relatively a little longer, and have a weaker midlink with fine crenulations; the upper premolar is relatively narrower and almost rectangular compared to *S. gilli* where it is rather triangular due to the broader posterior moiety; lower premolars are much narrower than in *S. gilli*. The obvious difference however, is in the skull. Even mature specimens of *S. gilli*, as estimated by dental wear, have a relatively small, low skull for *Simosthenurus* (though shorter than one of *Sthenurus* of equivalent breadth). In

contrast, even relatively young specimens of this new taxon have a large skull, roughly equivalent in size and shape to *Simosthenurus occidentalis*. The nasals are long, pointed and down-curved. The zygomae are heavy and deep with a prominent downward process opposite the first permanent molar M^2. On *S. gilli* the nasals are shorter and less curved, and there is no distinct process on the zygoma.

Group 3 Simosthenurus Species II: specimens P17244 (skull), P17245 (skull and jaws), P17253 (skull and jaws), P17250 (left and right jaws), P17251 (juvenile left jaw). (Table 3 and Figure 3). These *Simosthenurus* are tentatively referred to *S. orientalis* which previously has been known only from a few lower jaws. They have been compared with published data (Tedford 1966; Merrilees 1965, 1967; Bartholomai 1963; and Marcus 1976) of *Simosthenurus occidentalis, S. oreas, S. pales, S. antiquus, S. orientalis, S. brownei* and the unnamed large species from Strathdownie and Haystall Cave (Merrilees 1965), but only *S. orientalis* approximates them in lower dentition. The skulls are large, deep, broad and shortfaced: one specimen (P17245) is so well preserved that even the delicate postpalatine bar is retained intact.

One of the exciting aspects of this fossil discovery is the presence of more-or-less complete skeletons, associated with identifiable skulls. Several partial skeletons referable to *Sthenurus* s.1. have been recovered, and are being studied. As a preliminary guide, however, certain bones may be distinguished from *Macropus* thus:

femur robust, relatively greater shaft diameter, shaft curved convex forwards.

tibia robust, relatively shorter length and greater shaft diameter, slight sinuous curve when viewed anteriorly.

scapula: short and broad blade, very strong and long acromion process of spine, anterior moiety of blade reduced to distal corner only.

pelvis less triangular and more ovate obturator foramen than in *Macropus;* iliac blades broad, flaring; ventral (pubes) suture relatively shorter. Epipubic bone is a large broad blade, more than twice as long and wide as in *Macropus* of same pelvic size.

Cervical vertebrae very short, with the centrum about 19 mm long for a transverse diameter of up to 50 mm.

At least one of the skulls has a known associated partial skeleton. This is P17471, *Simosthenurus* sp. I, from area ①, and the remains consist of the pelvis and sacral vertebrae, right epipubic, both femora, left tibia and fibula, both arms, most cervical and dorsal vertebrae (only 5th cervical and 12th thoracic vertebrae are missing), some proximal caudal vertebrae, and a broken series of ribs. Other partial skeletons are less complete, at the moment, and there is some doubt about their associated skulls because they were not always collected during the same dive, or even the same expedition.

DISCUSSION

The deposit is so unusual and contains such well preserved material, that it readily lends itself to speculation concerning the mode of accumulation.

It is almost certain that the cave contains an assemblage of mixed ages, even without the modern rubbish dumped there. Material being added at the top of the rock pile must inevitably move by sheet wash, surface creep or other disturbances further down the slope. In doing so, however, it also would become dissociated and contribute to the extensive collection of isolated bones. This process has continued at least as long as the situation has approximated that of the present time, with the water level close to the surface, indeed, within easy reach of thirsty animals.

However, a large proportion of specimens are of extinct species, the bones often associated or even semi-articulated as in several instances of vertebrae. This implies that there have been no disturbances since the cadavers came to rest, and also the skeletons have an age of at least 10 000 years. The actual date of extinction of the Pleistocene megafauna is not known, but is more likely to be related to climatic/environmental changes associated with the end of the last glacial period than with any other simple cause, Martin (1967), Merrilees (1968) and others notwithstanding; and the present (Holocene) mild climatic regime is generally considered to have started 10 000 years ago (Bowler *et al.* 1976).

During the glacial stages of the Pleistocene, much seawater was removed as huge continental ice sheets, with the result that sea levels were universally depressed. Consequently, so too was the water-table in the Mount Gambier area. Accordingly, the water level in the cave would be lower, and possibly some considerable distance inside, even beyond the "twilight zone". It is quite possible that at the glacial maximum when sea levels were possibly as much as 130m lower than at present (Flint 1971) the cave was totally dry, and an animal could conceivably wander to the bottom and die on a rock and be undisturbed until the divers came. In reaching this position in the dark, however, it would scatter and break many of the remains already there. Yet the evidence is for numerous complete or partial skeletons resting undisturbed on rock slabs.

I am suggesting here, that the cave had a substantial lake when the "skeleton" individual entered it. This is based on an idea by B. Brawley, who noted that some distance from the entrance, there is a steplike break in the slope, about 7m below present water level (see fig. 1). If the water has reached that point, there would be a steep, possibly insuperable bank to the lake. In this scenario, any animal seeking water during a drought period, such as in the Late Pleistocene (Bowler *et al.* 1976), would have to stretch in order to drink, and if it stretched too far and fell in, it might not be able to clamber out, but would struggle until it drowned or died of exhaustion. The cadaver might float for a while, disintegrating slowly, or sink immediately to leave a beautifully laid-out skeleton on the bottom. The situation is somewhat like the Morwell fire-hole deposit of kangaroos excavated by Rich (1977), except that there has been no areal concentration of the skeletons by prevailing winds. The alternative hypothesis that the "skeleton" kangaroos entered a dry cave is not acceptable, since it requires some unknown form of protection for the skeletons until the rising groundwater had covered them.

Using hydrological data gathered in recent years, Mr. Aslin (pers. comm. 1979) has calculated that a water level at the break-in-slope, about 7 m below the present level, would correspond (at a first approximation) to a sea level drop of about 20m. Applying this amount to the sea level record curves figured by Chappell (1978: fig. 1·10) gives an age of 8 000-9 000 years, which is quite outside expectations based on fossil evidence elsewhere in Australia. No dated Holocene site has yielded *in situ Sthenurus* s.l. This suggests that the relationship between water table and sealevel in this area is not as simple as has been supposed. The age of the specimens must be sought by more direct methods.

With this in mind, an attempt was made in 1974 to obtain material for dating. Bottom sediments proved to be useless calcite flakes. There was hope of finding pollen in the fine silt filling one skull but it proved to be too oxidized. The age, therefore, will remain unknown until or unless associated charcoal or wood is found. However, circumstantial palaeoclimatological evidence, provided by work in western Victoria (Bowler *et al.* 1976) and elsewhere, suggests that the associated skeletal specimens might date from the cold arid period of the last glacial phase, approximately 17 000 to 14 000 years ago, if the scenario proposed above is correct.

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NOTE ADDED IN PROOF

The large but microdont species *Simosthenurus* sp. I of this paper has recently been recognized in cave deposits at Naracoorte, where it has been named *Sthenurus maddocki*. (Wells, R. & Murray, P., 1979: A new Sthenurine (Marsupialia, Macropodidae) from southeastern South Australia. *Trans. R. Soc. S. Aust* **103** (8): 213-219.)

TABLE 1. *SIMOSTHENURUS GILLI*, TOOTH DIMENSIONS (LENGTH x MAXIMUM WIDTH)

Tooth \ Specimen	Strathdownie & Haystall Mean Values*	P17248	P17265	P18326
lp^3	16·0 x 11·0	16·3 x 12·0	—	—
rp^3	15·8 x 11·5	16·8 x 12·2	15·5 x 11·3	—
lm^2	9·8 x 9·7	10·1 x 10·3	—	—
rm^2	10·2 x 10·3	10·1 x 10·4	9·5 x 10·1	—
lm^3	10·4 x 10·0	10·8 x 10·8	—	—
rm^3	10·9 x 10·6	10·8 x 10·9	10·5 x 10·4	—
lm^4	11·2 x 10·0	11·7 x 11·1	—	—
rm^4	11·6 x 10·8	11·0 x 11·0	11·3 x 10·4	—
lm^5	10·3 x 9·5	10·8 x 10·6	—	—
rm^5	10·8 x 10·3	10·5 x 10·5	—	—
lp_3	14·4 x 8·6	15·2 x 9·8	—	14·5 x 9·9
rp_3	15·0 x 9·0	14·9 x 9·5	—	14·4 x 10·0
lm_2	8·8 x 8·0	9·1 x 9·1	—	9·6 x 9·1
rm_2	9·1 x 8·4	9·7 x 9·0	—	9·6 x 8·8
lm_3	9·7 x 8·5	11·0 x 9·4	—	10·2 x 9·5
rm_3	9·9 x 8·9	10·9 x 9·4	—	10·5 x 9·6
lm_4	10·1 x 9·2	11·9 x 10·2	—	11·5 x 10·0
rm_4	10·4 x 9·6	12·0 x 10·4	—	11·4 x 9·8
lm_5	9·7 x 9·3	11·5 x 10·4	—	11·6 x 10·0
rm_5	10·0 x 9·9	11·5 x 10·5	—	11·4 x 10·1

*Data from Merrilees (1965); means taken to one decimal place

TABLE 2. *SIMOSTHENURUS* SP. I. TOOTH DIMENSIONS (LENGTH x MAXIMUM WIDTH)

Tooth \ Specimen	P17246	P17247	P17471	P17252	P17263
lp^2	9·5 x 8·1	—	—	—	—
lp^3	16·5 x 11·3	16·7 x 9·3	15·7 x 9·1	—	—
rp^3	—	16·2 x 9·6	15·7 x 9·3	—	—
lm^1	9·5 x 9·5	—	—	—	—
lm^2	10·9 x 10·3	10·2 x 10·4	10·0 x 10·0	—	—
rm^2	10·2 x 10·4	10·5 x 10·2	10·0 x 10·0	—	—
lm^3	11·3 x 10·7	10·6 x 10·8	10·5 x 10·5	—	—
rm^3	11·3 x 10·8	10·6 x 10·6	10·7 x 10·4	—	—
lm^4	11·3 x 11·2	10·6 x 10·8	10·2 x 10·6	—	—
rm^4	11·4 x 11·3	10·7 x 10·9	10·8 x 10·4	—	—
lm^5	11·0 x 11·1	10·2 x 10·6	10·8 x 10·8	—	—
rm^5	10·8 x 11·3	10·1 x 10·6	10·5 x 10·8	—	—
lp_3	15·8 x 8·5	15·7 x 7·4	—	15·6 x 7·9	15·5 x 8·0
rp_3	16·5 x 8·4	15·9 x 7·5	—	15·7 x 8·1	15·5 x 8·0
lm_2	11·1 x 9·1	11·1 x 8·2	—	11·0 x 8·5	11·1 x 8·5
rm_2	11·1 x 9·1	10·6 x 8·4	—	10·5 x 8·6	10·9 x 8·6
lm_3	11·9 x 9·8	11·5 x 9·2	—	11·1 x 9·5	—
rm_3	11·2 x 9·9	11·5 x 9·3	—	11·2 x 9·6	11·0 x 9·5
lm_4	11·7 x 10·3	11·7 x 10·0	—	11·8 x 10·2	—
rm_4	12·1 x 10·5	11·7 x 10·1	—	11·7 x 10·2	11·3 x 10·2
lm_5	11·3 x 10·5	11·3 x 10·1	—	11·7 x 10·3	—
rm_5	11·7 x 10·4	11·4 x 10·0	—	11·0 x 10·1	10·8 x 9·8

TABLE 3. *SIMOSTHENURUS* SP. II, TOOTH DIMENSIONS, (LENGTH x MAXIMUM WIDTH)

compared with *S. occidentalis, S. brownei, S. oreas and S. orientalis*

Tooth \ Specimen	P17244	P17245	P17253	P17249	P17498	*S. occidentalis* from Merrilees (1976), to one decimal place	*S. brownei* from Merrilees (1976), to one decimal place
$1p^2$	—	—	—	—	11·3 x 11·3	10·7 x 9·4	10·5 x 9·3
rp^2	—	—	—	—	11·4 x 11·2		
$1p^3$	18·7 x 13·5	18·1 x 12·2	17·3 x 12·7	17·6 x 13·1	—	17·6 x 12·7	15·9 x 12·0
rp^3	18·4 x 13·3	17·6 x 12·5	17·8 x 12·8	16·6 x 12·9	—		
$1m^1$	—	—	—	—	12·1 x 13·0	9·6 x 10·6	10·0 x 9·9
rm^1	—	—	—	—	12·0 x 12·8		
$1m^2$	12·3 x 14·4	11·8 x 13·6	13·0 x 13·8	12·9 x 13·3	14·0 x 14·2	10·9 x 11·1	10·8 x 10·9
rm^2	12·7 x 13·3	12·7 x 13·6	13·2 x 14·0	12·8 x 13·8	14·2 x 14·2		
lm^3	14·2 x 15·2	14·3 x 14·5	15·0 x 14·8	14·5 x 14·0	15·2 x 15·3	11·6 x 11·9	11·4 x 11·5
rm^3	14·9 x 15·1	14·6 x 14·7	15·0 x 15·1	14·2 x 14·4	15·2 x 15·4		
lm^4	14·9 x 15·0	14·8 x 14·4	14·8 x 14·8	15·8 x 14·0	15·7 x 15·2	12·1 x 12·1	11·8 x 11·5
rm^4	14·6 x 15·1	14·5 x 14·5	14·6 x 14·9	15·7 x 14·3	15·7 x 15·3		
lm^5	14·3 x 14·5	13·2 x 13·5	14·8 x 14·0	15·2 x 13·1	14·9 x —	11·4 x 11·7	11·2 x 11·0
rm^5	13·9 x 14·3	13·1 x 13·2	14·1 x 14·1	14·0 x 13·2	14·8 x —		

Specimen	P17251	P17245	P17253	P17250	P17499	*S. oreas* from Tedford (1966) AM MF 90	*S. orientalis* from Tedford (1966) AM F10201
lp_2	11·0 x 9·6	—	—	—	10·0 x 8·7	9·6 x 8·0	8·9 x 7·8	8·7 x 7·4	—
rp_2	—	—	—	—	10·2 x 8·7				
lp_3	—	15·1 x 10·1	15·8 x 10·1	15·8 x 9·7	—	16·7 x 10·1	14·4 x 9·6	14·4 x 8·3	17·0 x 10·7
rp_3	—	17·6 x 10·0	15·6 x 10·2	15·3 x 9·7	—				
lm_1	10·9 x 10·6	—	—	—	10·7 x 9·9	9·5 x 8·7	9·2 x 8·5	10·4 x 8·6	—
rm_1	—	—	—	—	10·3 x 9·8				
lm_2	13·0 x 12·3	12·2 x 12·1	12·7 x 10·9	11·7 x 11·0	14·2 x 12·1	10·5 x 9·5	10·2 x 9·1	13·0 x 10·4	14·0 x 11·2
rm_2	—	12·1 x 12·0	13·0 x 10·8	12·0 x 11·0	14·0 x 12·0				
lm_3	14·3 x 13·7	14·3 x 13·3	14·5 x 12·3	13·4 x 12·1	15·7 x 13·8	11·1 x 10·3	11·1 x 9·9	14·9 x 11·3	15·0 x 12·7
rm_3	—	14·8 x 13·0	15·2 x 12·3	13·8 x 12·3	16·0 x 13·5				
lm_4	15·7 x 14·1	15·1 x 13·8	15·2 x 13·1	14·5 x 12·8	15·8 x 14·0	11·8 x 10·9	11·6 x 10·2	16·4 x 12·2	15·2 x 13·2
rm_4	—	15·2 x 13·3	16·2 x 13·0	15·3 x 12·9	15·5 x 13·8				
lm_5	—	13·8 x 12·9	15·3 x 12·6	14·1 x 11·7	—	10·8 x 10·7	11·3 x 10·3	—	14·6 x 12·7
rm_5	—	13·8 x 12·8	15·2 x 12·7	13·5 x 11·9	—				

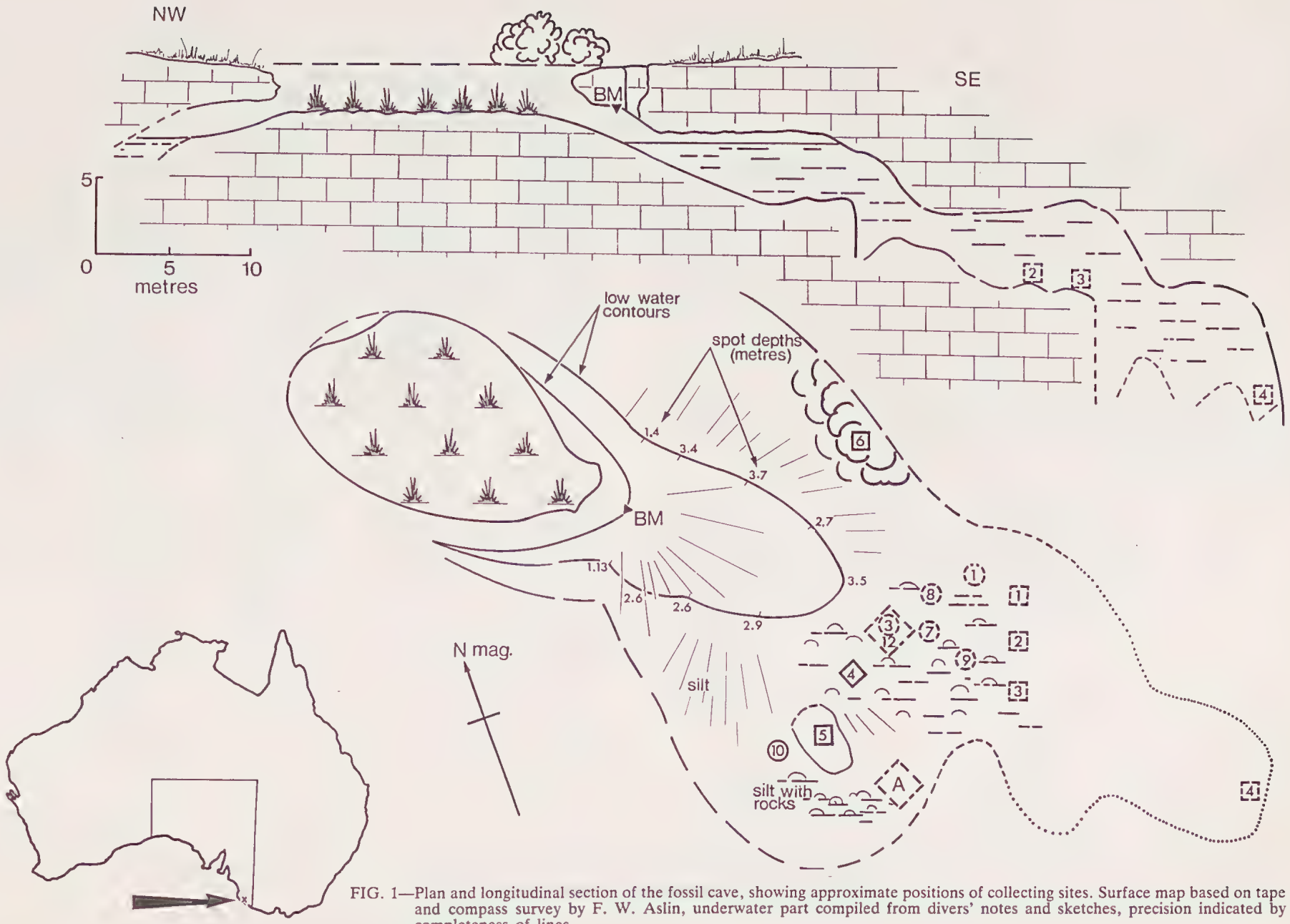


FIG. 1—Plan and longitudinal section of the fossil cave, showing approximate positions of collecting sites. Surface map based on tape and compass survey by F. W. Aslin, underwater part compiled from divers' notes and sketches, precision indicated by completeness of lines.

FIG. 2—A. *Simosthenurus gilli* Merrilees), P17248 Skull and jaws. Area 1.
B. *Simosthenurus* sp. I, P17247 Skull and jaws. Area 4.

FIG. 3—*Simosthenurus* sp. II, P17245 Skull and jaws. Area 2.

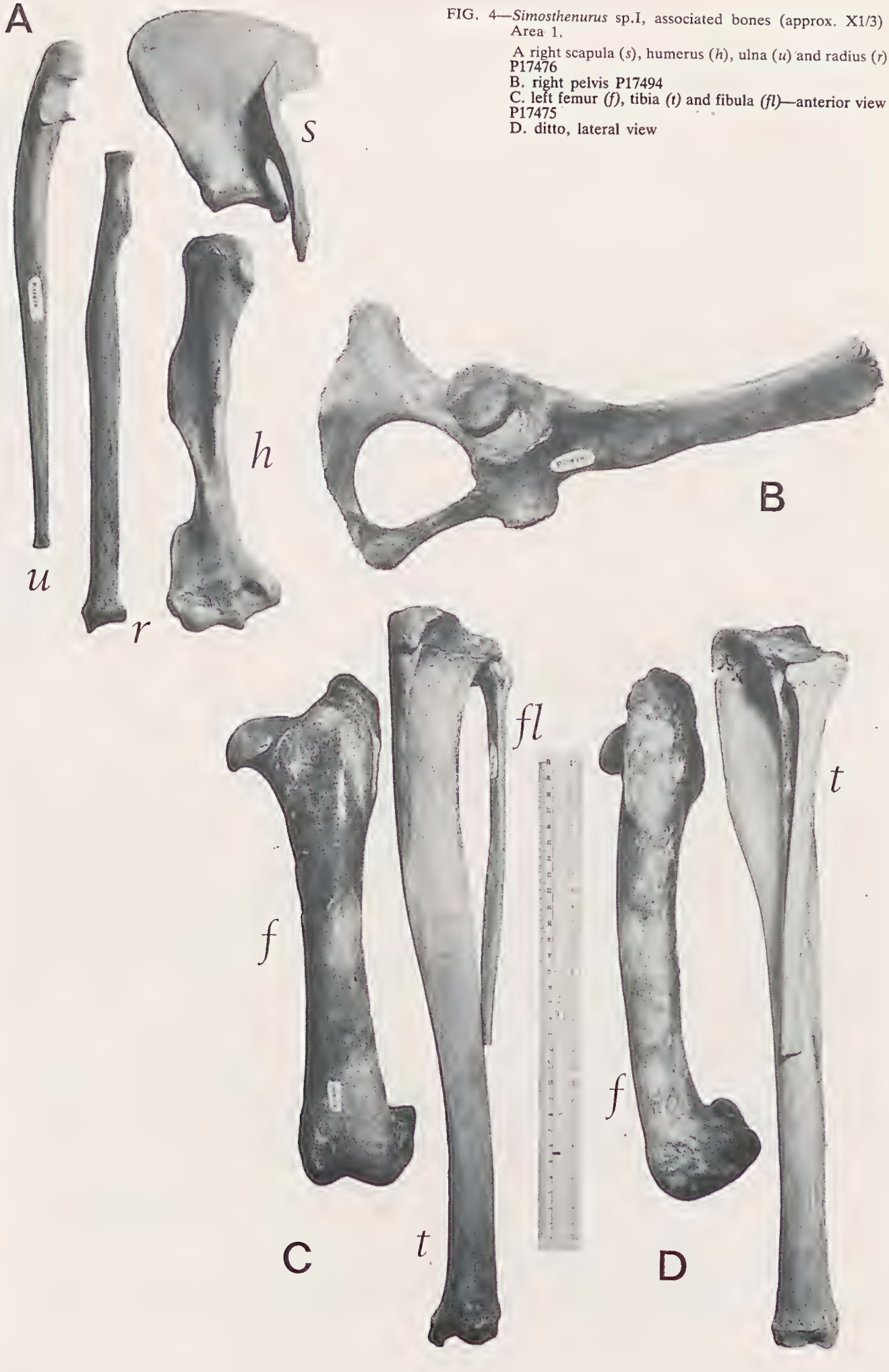


FIG. 4—*Simosthenurus* sp.I, associated bones (approx. X1/3) Area 1.

A right scapula (*s*), humerus (*h*), ulna (*u*) and radius (*r*) P17476
B. right pelvis P17494
C. left femur *(f)*, tibia *(t)* and fibula *(fl)*—anterior view P17475
D. ditto, lateral view

THE GENERA *LACCOBIUS* AND *NOTHYDRUS* (COLEOPTERA, HYDROPHILIDAE) IN AUSTRALIA AND NEW ZEALAND

by ELIO GENTILI

Museo del Seminario, Venegono Inf., 21040, Italy.

NATIONAL MUSEUM 26 MAR 1981 OF VICTORIA

Abstract

GENTILI, Elio. 1980. The genera *Laccobius* and *Nothydrus* (Coleoptera: Hydrophilidae) in Australia and New Zealand. *Rec. S. Aust. Mus.* **18** (7): 143-154.

A key to the Australian and New Zealand genera of the water beetle family Hydrophilidae, subfamily Hydrobiinae, tribe Hydrobiini, subtribe Hydrobiae is given and the Australian and New Zealand species of *Laccobius* Erichson, 1837 and *Nothydrus* Balfour-Browne, 1939 are described or redescribed and figured. *Laccobius* is represented in Australia by the species *L. (Notoberosus) zietzi* (Blackburn, 1895). *L. (Platylaccobius) clarus* n.sp., *L. (Platylaccobius) decipiens* n.sp., *L. (Macrolaccobius) marmoratus* Macleay, *L. (Macrolaccobius) matthewsi* n.sp., *L. (Macrolaccobius) bicaudatus* n.sp., *L. (Macrolaccobius) collium* n.sp., and *L. (Macrolaccobius) brittoni* n.sp., and in New Zealand by *L. (Platylaccobius) arrowi* d'Orchymont, 1925. *Nothydrus* is found only in Australia where it is represented by *N. australis* (Blackburn, 1891) and *N. montanus* (Blackburn, 1891). The differences between *Nothydrus* and *Laccobius* are discussed and other genera to which *Nothydrus* may be closely related are noted.

INTRODUCTION

Members of the genera *Laccobius* and *Nothydrus* are aquatic Coleoptera found in both stagnant and running freshwater. The first genus is widespread, being absent only from South America, the second is Australian. They belong to the family Hydrophilidae, subfamily Hydrobiinae, tribe Hydrobiini, subtribe Hydrobiae (see d'Orchymont 1942).

The genera of Hydrobiae d'Orchymont, 1919, in Australia and New Zealand may be distinguished by the following key.

Key to Australian and New Zealand Hydrobiae

1. Hind trochanters with an elongate apex and separated from the femora at their tip. Elytra without parasutural furrows. Six abdominal segments, the sixth somewhat retractile into the fifth ..... *Laccobius* Erichson, 1837

   Hind trochanters not elongate. Elytra with parasutural furrows. Five abdominal segments 2

2. (1) Regular longitudinal lines of punctures on elytra. Antennae 9-segmented. Meso- and meta-tarsi with the first article shorter than second. Larger body size: length more than 4 mm 3

   Elytral punctures not, or only on hind and lateral surface, arranged in longitudinal lines but randomly disposed. Antennae 7-9 segmented. Size normally less than 4 mm 5

3. (2) Meso- and meta-tarsi without long swimming setae. Meso- and meta-femora without hydrofugal hairs. Body posteriorly enlarged .... *Hybogralius* d'Orchymont, 1942.

   Upperside of meso- and meta-tarsi with long swimming setae. Meso- and meta-femora with hydrofugal hairs ... 4

4. (3) Pro-, meso-, and anteriorly meta-sternum keel-shaped in the middle ..... *Limnoxenus* Motschulsky, 1853

   Only the mesosternum sometimes keel-shaped in the middle ..... *Hydrobius* Leach, 1815

5. (4) Prosternum keel-shaped in the middle. Hind femora without dense hydrofugal hairs *Paracymus* Thomson, 1867

   Prosternum without any longitudinal keel. Hind femora, at least anteriorly, with dense hydrofugal hairs 6

6. (5) Labium deeply excavated. Fifth antennal article cupuliform. Elytral rows posteriorly conspicuous ..... *Nothydrus* Balfour-Browne, 1939

   Labium anteriorly not excavated. Elytra without longitudinal rows of punctures. Fifth antennal article normally shaped ..... *Anacaena* Thomson, 1859

SYSTEMATICS

The genus *Laccobius* is recognizable chiefly by the following features. A convex, oval body, not capable of rolling up. Head with a Y-shaped suture and entire eyes; sometimes the male with two specula under the labium; antenna 8-segmented (5+3), the fifth article asymmetrically cup-shaped; maxillary palpi shorter than antennae, with penultimate article shorter than ultimate. Pronotum without furrows or keels; prosternum keel-shaped in the middle; anterior tarsi expanded in the male. Scutellum a subequilateral triangle; mesosternum usually with a longitudinal keel and a small tooth in front of the keel; middle femora without hydrofugal hairs (sometimes these are represented by a small basal tuft, but not in Australian specimens); elytra, as a rule (and always in Australian species), without parasutural furrows. Wings provided with cantharidiform nervation. Metasternum without any keel, in the middle with a small glabrous area; hind trochanters with an elongate apex and separated from the femora at their tip; hind femora without hydrofugal hairs; hind tibiae usually curved. Six abdominal segments, without any keel; the sixth somewhat retractile into the fifth. Pro, mid- and hind tarsi with the first article shorter than the second, and the last shorter than the others combined.

The subgenera in our region are the following:

I. *Notoberosus* Blackburn, 1895 (syn. n. : *Ortholaccobius* Ganglbauer, 1904). It has straight hind tibiae. This feature is also

typical of the subgenus *Ortholaccobius* Ganglbauer, 1904; the two subgenera, in my opinion, are to be united. The differences are chiefly two, both in the male of *zietzi (Notoberosus):* the specula and the lack of a mesoternal keel. These differences disappear in the female, and are therefore inadequate to form the basis for the separation of two subgenera. *Notoberosus* are very numerous in New Guinea and in surrounding islands. The other three subgenera have curved hind tibiae.

II. *Microlaccobius* Gentili, 1974 is characterized by the pattern of the elytral series, alternately more regular, more impressed, more punctate, and less regular, less impressed, less punctate. The subgenus appears to be the most primitive, owing to lack of specula, and to the small, weakly chitinized and simply structured aedeagus.

III. *Macrolaccobius* Gentili, 1974 is, like the preceding, a subgenus widespread in the Palaearctic, and Oriental regions. It has more complex features: the elytral series more irregular, an evolved aedeagus, and sometimes specula and tufts of hairs on the middle femora.

IV. *Platylaccobius* Gentili, 1974 is characterized by the lack or reduction of the elytral seriation. The body is normally flat, more so than in *Micro-*and *Macrolaccobius,* and the aedeagus more complex than in *Microlaccobius.*

Key to species

1. Hind tibiae straight: subg. *Notoberosus . . . zietzi* Blackburn
   Hind tibiae curved 2

2. (1) Elytral punctures randomly placed and not forming any pattern of rows or lines, rarely in sparse and incomplete lines, rows or whorls subg. *Platylaccobius* 3

   Elyral punctures in about 20 longitudinal curved lines... 5

3. (2) Pronotum without a dark spot, or the dark spot is very feeble and indistinct; aedeagus as in Fig. 2 a, b *clarus* n. sp.

   A distinct dark spot on the pronotum..... 4

4. (3) Body length twice (or more than twice) the breadth. Australian species. Aedeagus as in Fig. 2 c, d *decipiens* n.sp.

   Body length less than twice the breadth. New Zealand species. Aedeagus as in Fig. 3 a, b ... *arrowi* d'Orchymont

5. (2) Elytral punctures alternately (in primary series) more regular, more impressed and more punctate, and in secondary series, not regular, weakly impressed and scarcely punctate. Size small, subg. *Microlaccobius* ... 6

   Elytral punctures are in series not so alternated; some of them are irregular, with mixed small and large punctures, subg. *Macrolaccobius* 7

6. (5) Labium extended posteriorly in the shape of a V reaching the postlabium; hind margin of propygidium deeply excised: aedeagus as in Fig. 4 a, b . . . *marmoratus* MacLeay

   Hind margin of the labium slightly sinuous medially; propygidium not excised; aedeagus as in Fig. 4 c, d *matthewsi* n.sp.

7. (5) A large preocular patch. Hind apex of each elytron separated from the other, leaving a large triangular space between them ..... *bicaudatus* n.sp.

   No preocular patches. Hind apex of each elytron close to the other in resting position. Smaller body size 8

8. (7) Aedeagus wider, more complex, as in Fig. 5 a, b *collium* n.sp.

   Aedeagus narrower and simple, as in Fig. 5 c, d . *brittoni* n.sp.

1. *Laccobius (Notoberosus) zietzi* (Blackburn 1895) (Figs 1 a, b; 7)

Blackburn, 1895 *(Notoberosus);* Zaitzev, 1908 *(Notoberosus);* Knisch, 1924 *(Notoberosus);* d'Orchymont, 1925; 1937; 1948.

Body length 3·0-3·9 mm; breadth 1·35-1·75 mm. Elongated, more than twice as long as wide.

Labium dark or metallic, sometimes with pale sides, or entirely pale except in middle; surface alutaceous; anterior edge sinuous in male, straight in female, the posterior curved. Head dark or metallic, with large preocular patches reaching eyes; the patches sometimes united; surface very slightly alutaceous, with fine and scattered punctures. Eyes taken together scarcely smaller than intervening distance. Pronotum yellowish, sometimes reddish, or with some small evanescent dark spots in central area; smooth in male, hardly shagreened in female. Corners of pronotum rounded, the hind corners very widely so (more than in *minutus).* Scutellum pale or dark, with very thin punctures. Elytra yellowish, with or without a number of dark spots, but always pale on edges; the punctures are slightly darkened, numerous, irregularly scattered (but tending to form 5-6 series, chiefly near the suture), of various size. Elytral apex nearly vertical.

Underside dark, except head, pronotum, palpi, antennae and legs. Labium of male has two specula nearly circular in shape. The postlabium (or mentum) is rugose, its anterior margin sinuous. Prosternum short, keel-shaped; mesosternum weakly but distinctly keel-shaped in female, gibbous in male, the keel not anteriorly abrupt. Hind margin of fifth abdominal segment deeply sinuous in male. Antennae 8-segmented (Blackburn (1895) enumerated 6 segments); legs slender, the hind tibiae straight. Aedeagus (Fig. 1 a, b) 1/3·5 of body length; tegmen longer than parameres, which are rounded at apices; median lobe sulcate and pointed at apex.

South Australian species (Fig. 7), with the following distribution: Lake Callabonna (type locality, 10 ex., leg. A. Zietz); River Wakefield,

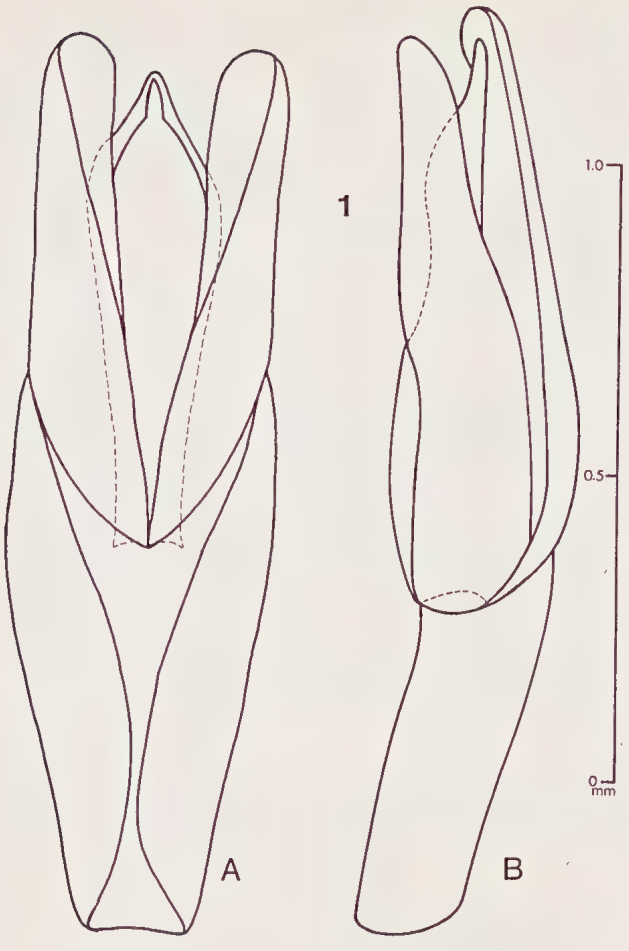


Fig. 1—Aedeagus of *Laccobius zietzi*, lectotype, Lake Callabonna, South Australia: A, frontal view, B, lateral view. Prepared in euparal, soluble in absolute alcohol, like the following aedeagi. The same scale applies to all of the text. Figures 1-6.

near Adelaide (2 ex.); Levi Creek, 6 km NW Big Perry Spring 28° 19' 2S, 136° 16' 1E (17 ex., leg. J. A. Herridge, 7.XII.1974); Coopers Creek, Ferry Crossing (1 ex., leg. J. A. Herridge, 30.XI.1974). The specimens are in the South Australian Museum, Adelaide, and in the Museums of Verona and Milano, Italy.

Lectotype: South Australian Museum, Adelaide; 3·4 x 1·55 mm; labels: L. Mulligan/L. Callabonna A. Zietz/9.6580 *Notoberosus zietzi* Blkb. L. Callabonna type /1. ♂ Paratypus 2. Lectotypus; *Laccobius (Notoberosus) zietzi* (Blackburn 1895); det. E. Gentili 1976. Another 7 specimens in the S.A. Museum labelled in the same manner as the lectotype are to be considered paratypes.

2. *Laccobius (Platylaccobius) clarus* n.sp.
(Figs. 2 a, b; 8)

Body length 2·4-3·1 mm; breadth 1·2-1·7 mm. Elongated, nearly twice as long as wide, very slightly convex.

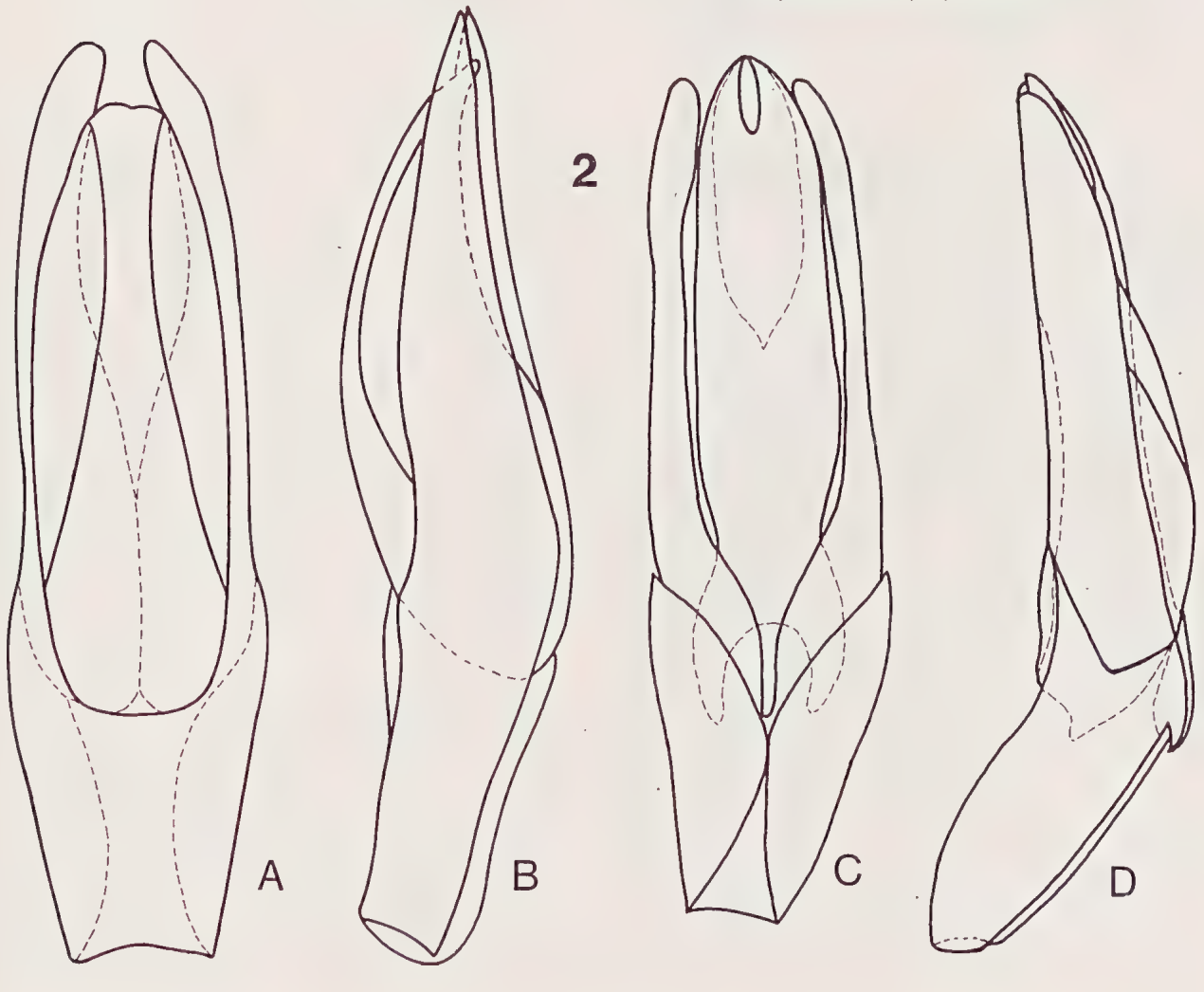


Fig. 2—A, B, Aedeagus of *Laccobius clarus*, holotype, Adelaide, South Australia: A, frontal view, B, lateral view; C, D, Aedeagus of *Laccobius decipiens*, holotype, Tamworth, New South Wales: C, frontal view, D, lateral view.

Labium large, dark or metallic with pale angles, alutaceous, with anterior edge straight, the posterior curved. Head dark or metallic, with large preocular patches reaching eyes, the patches taken together are of the same width as intervening space, the whole surface shagreened and closely punctured. Prothorax testaceous, with a small evanescent dark spot in its central-anterior area; the surface shagreened and punctured like the head; fore margin sinuous, slightly prominent in centre (in *arrowi* it is straight). Scutellum pale or scarcely darkened, with a number of very thin punctures. Elytra pale, testaceous (sometimes darkened owing to *'actio post mortem');* the punctures are numerous, larger than those of pronotum, but similar to each other in size, irregularly scattered, darkened on elytral disc, clear at the edges; the humeri are conspicuous. Posterior apex ogival.

Underside dark, excepting head, pronotum, abdominal sides, palpi, antennae and legs. Postlabium flat, not rugose, with very fine punctures; the fore margin curved. Prosternum short (its length is ½ that of the gula), keel-shaped. Mesosternum keel-shaped on its anterior ⅔, with an anteriorly abrupt tooth on its fore apex. Hind margin of propygidium nearly straight in female, lightly curved in male. Palpi, antennae and legs of the normal pattern. Aedeagus (Fig. 2 a, b) 1/3·7 of body length, with a large median lobe, shorter than parameres; the median lobe sometimes shows a small mobile strut near the apex.

The species is known from South Australia, New South Wales and Queensland (Fig. 8), and is among the commonest Australian *Laccobius*. South Australia: Adelaide (type locality, 11 ex., leg. T. Blackburn et al.); Hindmarsh Falls (2 ex., leg. E. B. Britton-N. Tindale, at light, 23-24.XII.1961); Well, near Oraparinna (1 ex., leg. G. F. Gross, at light. 12.II.1956); Karoonda to Peebinga (2 ex., leg. G. E. H. Wright); Murray River, E Adelaide (1 ex., leg. H. S. Cope); Frome River crossing of Birdsville Track, near Maree (4 ex., leg. G. F. Gross, at light, 25.X. 1966); 10 km N Maynards Well, N Flinders Range (1 ex., leg. J. A. Herridge, at light, 11.XII.1974); Brachina Gorge, Flinders Range (6 ex., leg. J. A. Herridge, at light, 14.XII.1974); Muddle Bore, 35 km NE Billa Kalina (3 ex., leg. J. A. Herridge, at light, 4.XII.1974); Margaret River, 10 km SE Coward Springs (2 ex., leg. J. A. Herridge, at light, 3.XII.1974); Marree Racecourse (13 ex., leg. J. A. Herridge, at light, 1.XII.1974); Levi Creek, 8 km NW Big Parry Spring 28° 19' 2S, 136° 16' 1E (1 ex., leg. J. A. Herridge, at light, 7.XII. 1974); Coopers Creek, Ferry Crossing (38 ex., leg. J. A. Herridge, at light, 30.XI.1974); 5·5 km WNW Myrtle Springs (1 ex., leg. E. G. Matthews, 2-3.III.1975); 37 km W of Anna Creek (1 ex., leg. E. G. Matthews, 8-9.III.1975); Coward Springs (1 ex., leg. G. F. Gross, at light, 9.XI.1966). New South Wales: Murray River, 50 mi. W of Wentworth (14 ex., leg. A. Neboiss 22.XI.1967). Queensland: Cunnamulla (1 ex., leg. H. Hardcastle); Dear River, 23° 13' S, 144° 04' E, 31 km NW by N of Longreach (3 ex., leg. M. S. Upton, 22.X.1975); Birdsville (4 ex., leg. J. Blyth, 11.V.1975). Australia (2 ex. Coll. Fairmaire; 2 ex. Pascoe Coll.).

Holotype: British Museum; 2·7 × 1·35 mm; labels: Australia: Adelaide /Sharp Coll. 1905-313 / *Laccobius (Platylaccobius) clarus* n. sp. E. Gentili det. 1976 / ♂ Holotypus.
Allotype: British Museum; 2·9 × 1·45 mm; similar labels. the Paratypes are those of the former list; they are in the following Natural History Museums: British Museum; Musée de Paris; Museo di Verona; Museo di Milano; South Australian Museum; CSIRO; National Museum of Victoria.

3. **Laccobius (Platylaccobius) decipiens** n. sp. (Fig. 2 c, d; 7)

d'Orchymont, 1925 *(L. marmoratus).*

Body length 2·9-3·9 mm; breadth 1·5-2·0 mm. Elongated, oval, nearly twice as long as wide.

Labium entirely dark or metallic, alutaceous, with a straight anterior margin. Head dark or metallic, with preocular patches reaching eyes, but somewhat smaller than in *clarus;* surface shagreened and closely punctured, the punctures more numerous and more impressed than in *clarus.* Pronotum pale, testaceous, with a dark spot longer than wide, reaching the fore margin more widely than the hind, and slightly expanded in the hind half; surface similar to that of head, shagreened and punctured; fore margin sinuous, slightly prominent in the centre. Scutellum dark. Elytra pale, sometimes with nebulous spots or darker lines (post mortem changes?); the punctures are scattered irregularly and very densely, sometimes suggesting longitudinal series. Apices of elytra ogival, but often the elytra are separated.

Underside dark, except antennae, palpi and most of legs, and sometimes borders of prothorax and abdomen. Labium without specula; postlabium flat, granulate. Prosternum keel-shaped; mesosternum keel-shaped on the hind 2/3, with an anterior tooth on the keel. Hind margin of propygidium straight in both sexes. Palpi, antennae and legs of the normal pattern. Aedeagus (Fig. 2 c, d) ca. 1/4·7 of the body length, the median lobe somewhat narrower than in *clarus,* but slighty longer than the parameres.

The species is known from Victoria, New South Wales and Queensland (Fig. 7), and seems to be rarer than *clarus*. Victoria: Thurra River, Cape Everard (2 ex., leg. A. Neboiss, 22.III.1970); Deddick River, ½ km above Snowy R. junction (10 ex., leg. A. Neboiss, 13.XII.1976); Thomson River, 1 km upstream Cowwarr Wier (2 ex., leg. A. Neboiss, 26.X.1973); Snowy-Deddick River junction (1 ex., leg. A. Neboiss, 14.XII.1976); Snowy River, 5 km below Deddick River junction (1 ex., leg. A. Neboiss, 14.XII.1976); Rainbow Ck., Cowwarr—Seaton Rd., 18.II.1977, N.M.V. Survey Dept., GRES (1 ex.). New South Wales: Tamworth (type locality, 1 ex., leg. A.M. Lea); Jenolan Caves (14 ex., leg. J. C. Wiburd 1864); Volumla (1 ex., leg. J. Sedlacek, I.1954); Tumut River (2 ex., leg. J. Sedlacek, 1955). Queensland: Cairns (1 ex., leg. J. Sedlacek 1951); N Queensland (3 ex., leg. T. Blackburn).

Holotype: Institut R. Sciences Naturelles de Belgique, Brussels; 3·5 × 1·75 mm; labels: Coll. R.I. Sc. N.B. Australia 1864 Tamworth N.S.W. Ex Coll. d'Orchymont/Coll. et det. d'A. Orchymont: *Notoberosus marmoratus* M. ; R.M.H.N.B. 15.962/ *Laccobius (Platylaccobius) decipiens* n.sp. E. Gentili det. 1976 / ♂ holotypus.

The Paratypes are those of the former list; they are in the following Natural History Museums: South Australian Museum; National Museum of Victoria; California Academy of Sciences; Bishop Museum, Honolulu; Museo di Verona; Museo di Milano.

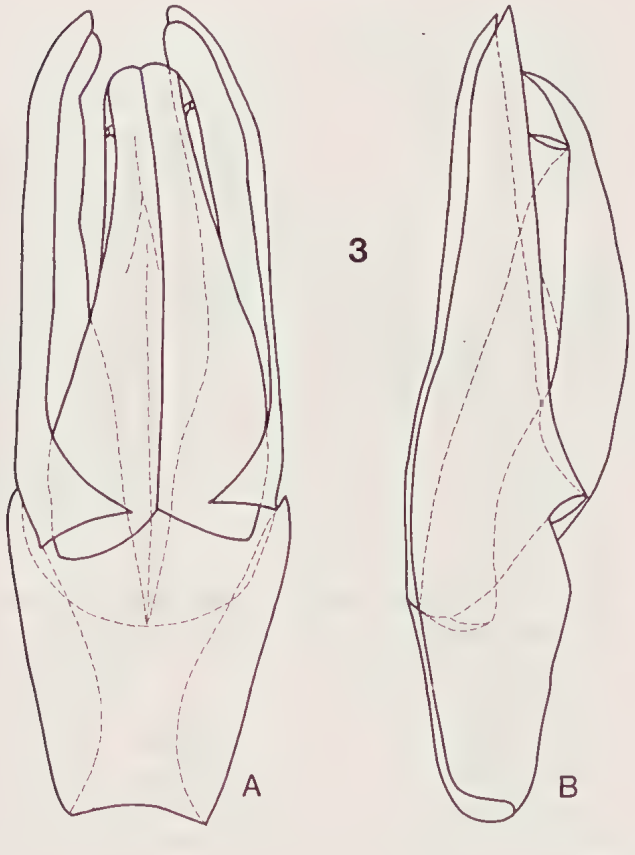


Fig. 3—Aedeagus of *Laccobius arrowi*, Rotorua Co., Waimangu Stream, N. Island, New Zealand: A, frontal view, B, lateral view.

4. **Laccobius (Platylaccobius) arrowi** d'Orchymont, 1925 (Figs. 3 a, b; 7)

d'Orchymont, 1925; 1937; Winterbourn, 1970 *(mineralis);* 1973 *(mineralis).*

Body length 2·3-3·5 mm; breadth 2·2-1·7 mm. Oval, slightly convex, not much elongated (breadth less than half of length).

Labium dark or metallic, alutaceous, punctured, with fore margin straight, the hind curved. Head also dark or metallic, alutaceous, with fine scattered punctures; preocular patches pale and wide, as in *decipiens*. Pronotum dark on disc, pale on sides, the border of the colours uncertain; the dark spot is normally wider than in *decipiens*. Anterior margin of pronotum, between the lateral corners, almost straight (in contrast to *clarus* and *decipiens);* the surface alutaceous and punctured as on head. Scutellum dark. Elytra pale, sometimes darkened by post-mortem colour; the punctures are scattered, rarer than in *decipiens*, darkened on disc, pale on edges of elytra.

Underside dark, except palpi, antennae and most of legs (femora are for the most part darkened). Labium without specula; postlabium flat, with scarcely visible punctures. Prosternum keel-shaped; mesosternal keel with a tooth on fore end. Palpi, antennae and legs of normal pattern. Aedeagus (Fig. 3 a, b) ⅓ of body length, the median lobe shorter than parameres and very complex.

The species is known from New Zealand (Fig. 7): Otago, S Island (type locality, 10 ex., leg. Lewis 1901); Copland River, Welcome Flat, South Westland, S Island (Winterbourn, 1973); Rotorua Co., Waimangu Stream, N Island (4 ex., leg. K. A. J. Wise, 10.V.1971); Taupo, Waipuwerawera Stream, N Island (type locality of *mineralis;* 2 ex., leg. M. Winterbourn VI.1966; cfr. Winterbourn, 1970); Taupo, Waipahihi Stream, N Island (2 ex., cfr. Winterbourn, 1970); Waiotapu (Winterbourn, 1973); N. Swale (1 ex., of the British Museum). These specimens are in the British Museum, Brussels Museum, Auckland Museum and Verona Museum.

Holotype: British Museum; 2·75 x 1·5 mm; labels: Holotype/type/Otago Lewis 1901/A. d'Orchymont det. *Laccobius* s.str. *arrowi* d'Orchym./Sharp coll. 1905-313 (the anterior tarsi are all lost, but the description is of a male).

Paratypes: I know of two paratypes from the type locality in the British Museum and in Brussels Museum.

Laccobius mineralis Winterbourn, 1970 is in my opinion the same species as *arrowi*. This opinion is based on the observation of both the typical specimens of *arrowi* and of one specimen from the type locality of *mineralis*, determined by Winterbourn and accompanied by 4 *"mineralis"* taken from the same area by K. A. J. Wise, as well as on the description of *mineralis*. These are the differential characters proposed by Winterbourn (1970): (1) The size: 2·3-2·4 mm for *arrowi;* 3·2-3·5 mm for *mineralis*. But I obtained, on 4 beetles from 4 different stations, these measurements: 2·65 x 1·35; 2·75 x 1·45; 2·95 x 1·5; 3·15 x 1·55 mm. They evidently are a continuous series. (2) The anterior angles of the pronotum are rounded in *arrowi* , and the pronotum is deeply curved anteriorly, while in *mineralis* the anterior angles are acute giving the anterior margin a sinuous appearance. This is really the same thing: the anterior angles are really rounded, but observed from above they appear acute; the sinuate appearance is due to the articulate corners that make the fore margin deeply curved. (3) The colour of the pronotum of *arrowi* is pale on the borders, of *mineralis* completely brown. Winterbourn observed possibly a melanic specimen. (4) The antennae are 8-segmented, not 6-segmented as observed by Winterbourn. The Holotype of *mineralis* is in the Auckland Institute and Museum, New Zealand.

5. **Laccobius (Microlaccobius) marmoratus** (Macleay, 1873)
(Figs. 4 a, b; 7)

Macleay, 1873 *(Philhydrus);* Zaitzev, 1908 *(Enochrus);* Knisch, 1924 *(Enochrus);* cfr. d'Orchymont, 1925.

Body length 2·1-2·4 mm; breadth 1·1-1·3 mm. Elongated, oval, nearly twice as long as its width.

Anterior margin of labium arcuate. Labium and head dark, with a greenish metallic reflection; preocular pale patches before eyes are half the breadth of each eye. Surface (observed at 60 x) shagreened, without punctures. Ratio between breadth of eyes and of interposed space is ¾. Pronotum testaceous, with a dark metallic spot which reaches posterior but not anterior margin; this spot is narrower than space between eyes, and its fore border is divided into two parts. Surface shagreened more conspicuously than head, and with some impressed punctures on discal area. Scutellum alutaceous like the head, with very fine punctures. Elytra testaceous, with some dark nebulosity on disc and paler edges; the series of punctures alternately more and less impressed.

Labium without specula, but with a border attached to the postlabium tracing a triangle. Postlabium flat, slightly wrinkled when observed at 60 x. Prosternum keel-shaped; mesosternal keel is pyramidal and present only on hind part of the mesosternum; glabrous metasternal line somewhat excavated. Hind margin of propygidium deeply excavated. Palpi, antennae and legs testaceous; the legs are normally shaped, elongated. Aedeagus ¼ of body length; ratio tegmen/parameres ⅔; structure simple (fig. 4 a, b), the parameres scarcely longer than median lobe.

Lectotype: CSIRO, Canberra; 2·2 x 1·1 mm (elytra 1·45 mm); labels: Gayndah/On permanent loan from Macleay Museum, University of Sydney/ *Laccobius marmoratus* (Macleay) ♂ Lectotypus E. Gentili 1975/syntype/*Philhydrus marmoratus*, Macl., Gayndah. Paratypes: The Australian Museum, Sydney; labels: red circular label/719509/*Philhydrus marmoratus* Mc. L. W. Gayndah the Holotype/ 1. Allolectotypus ♀ 2. Paratypus ♀ *Laccobius marmoratus* Macleay, E. Gentili 1976.

The species is known only from the type locality. Gayndah is a mountain town about 320 km north of Brisbane, Queensland (Fig. 7).

6. **Laccobius (Microlaccobius) matthewsi** n.sp.
(Figs. 4 c, d; 8)

Body length 1·6-2·5 mm; breadth 0·9-1·35 mm, oval, moderately elongated, the length less than twice the width.

Head and labium dark metallic, with two yellowish preocular spots before the Y-shaped suture or, sometimes, before the eyes; these spots of same width as eyes or sometimes less. Surface clearly alutaceous and weakly punctured. Anterior border of labium regularly curved; distance between eyes more than width of eyes. Pronotum testaceous, with a dark or metallic central patch; the patch has uncertain borders and is normally larger anteriorly, reaching level of eyes. Surface shagreened like that of head, but with stronger punctures. Scutellum dark or metallic, micro-reticulated. Elytra testaceous, sometimes with a dark spot near centre of suture. The series of punctures are clearly alternating strongly impressed (primary), or weakly (secondary). Elytral apex rounded.

Underside dark; palpi, antennae and legs testaceous-yellowish. Labium without specula, the hind margin straight (in contrast with *marmoratus).* Prosternum keel-shaped; mesosternum with a keel on posterior part, the keel having an anterior tooth; propygidium posteriorly straight (another contrast to *marmoratus).* Aedeagus ⅕-⅙ of body length; parameres narrower than *marmoratus* in frontal view, and not narrowing out in apical part in lateral view (Fig. 4 c, d).

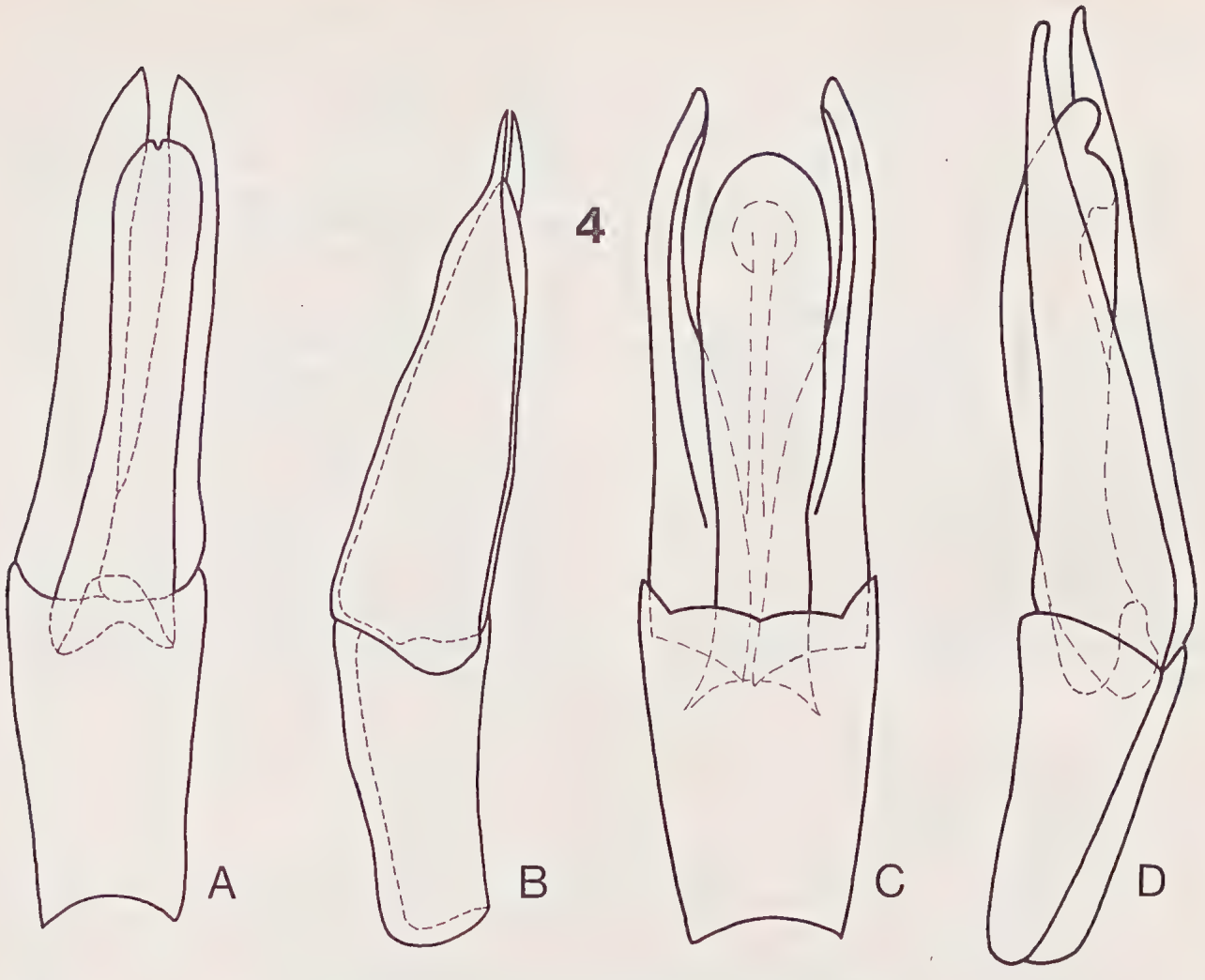


Fig. 4—A, B, Aedeagus of *Laccobius marmoratus*, lectotype, Gayndah, Queensland: A, frontal view, B, lateral view; C, D, Aedeagus of *Laccobius matthewsi*, holotype, Parachilna, Flinders Range, South Australia: C, frontal view, D, lateral view.

This is one of the more common *Laccobius* of Australia (Fig. 8). Western Australia: Mullewa (1 ex., leg. Harvard Exp. Darlington, 2.IX.1931); Carson Escarpment 14° 49′ S, 126° 49′ E (2 ex., leg. I.F.B. Common-M.S. Upton, 9-15.VIII.1975); Langi Crossing, 10 m (5 ex., leg. E.S. Ross-D.Q. Cavagnaro, 13.X.1962); Milly Milly, 300 m (1 ex, leg. E. S. Ross-D. Q. Cavagnaro, 6.X.1962); Northern Territory: Bessie Spring, 16° 40′ S, 135° 51′ E, 8 km ESE of Cape Crawford (7 ex., leg. M.S. Upton 26.X.1975); Nabarlek Dam, 12° 20′ S, 133° 19′ E, 15 km S by W of Nimbuwah Rock (1 ex., leg. E.G. Matthews, at light, 2.XI.1973); South Australia: Parachilna, Flinders Range (1 ex., type locality); Queensland: Coen, C. York (4 ex., leg. Harvard Exp. Darlington, V. 1932); Crystal Creek, 23 mi. SSE of Ingham, 18° 58′ 5″ S, 146° 16′ E (7 ex., leg. Britton-Misko, at light, 9.XII.1968); Cairns Distr. (2 ex., leg. A.M. Lea); New South Wales: Moruya River, Araluen (9 ex., leg. E.B. Britton, 27.XII.1965); Manar Creek, Canberra Coast Road (1 ex., leg. E.B. Britton-S. Misko, 18.V.1967); Vicinity of Jenolan Caves (4 ex., leg. J. C. Wiburd); Tumut River (1 ex., leg. J. Sedlacek, 1955); Victoria; Thurra River, Cape Everard (1 ex., leg. A. Neboiss, 22.III.1970); Deddick River, ½ km above Snowy River junction (4 ex., leg. A. Neboiss, 13.XII. 1976); Meredith (1 ex., leg. A. Neboiss, 12-13.II.1959); Eppalock Res. Redesdale (1 ex., leg. A. Neboiss, 27.XI. 1967).

Holotype: South Australian Museum, Adelaide; 2·3 × 1·25 mm; labels: Parachilna, Flinders Range / *Laccobius matthewsi* n.sp. E. Gentili 1976 / ♂ Holotypus.

Paratypes: those of the preceding list; they are in the following Museums: South Australian Museum; National Museum of Victoria; CSIRO; Museum of Comparative Zoology of the Harvard University; California Academy of Sciences; Bishop Museum, Honolulu; Museums of Verona and Milano, Italy.

7. **Laccobius (Macrolaccobius) bicaudatus** n.sp.

Body length 3·2 mm; breadth 1·5 mm; elongated, more than twice as long as wide.

Labium and head dark with metallic reflections; two pale patches as wide as eyes, situated before the latter; the whole surface shagreened, punctured, the punctures thicker and stronger behind lateral branches of Y-shaped suture. Fore margin of labium regularly arcuate. Pronotum pale, testaceous, the dark metallic spot oval, filling only central area of disc without reaching borders, the surface shagreened and punctured like vertex. Fore margin sinuous, with the median convexity equal to the lateral ones (these are scarcely developed, less than in other *Laccobius).* Elytra testaceous, hardly paler on apex and sides; the punctures without dark rings, the series not always conspicuous, more irregular on the apical zone. Elytral apices divergent.

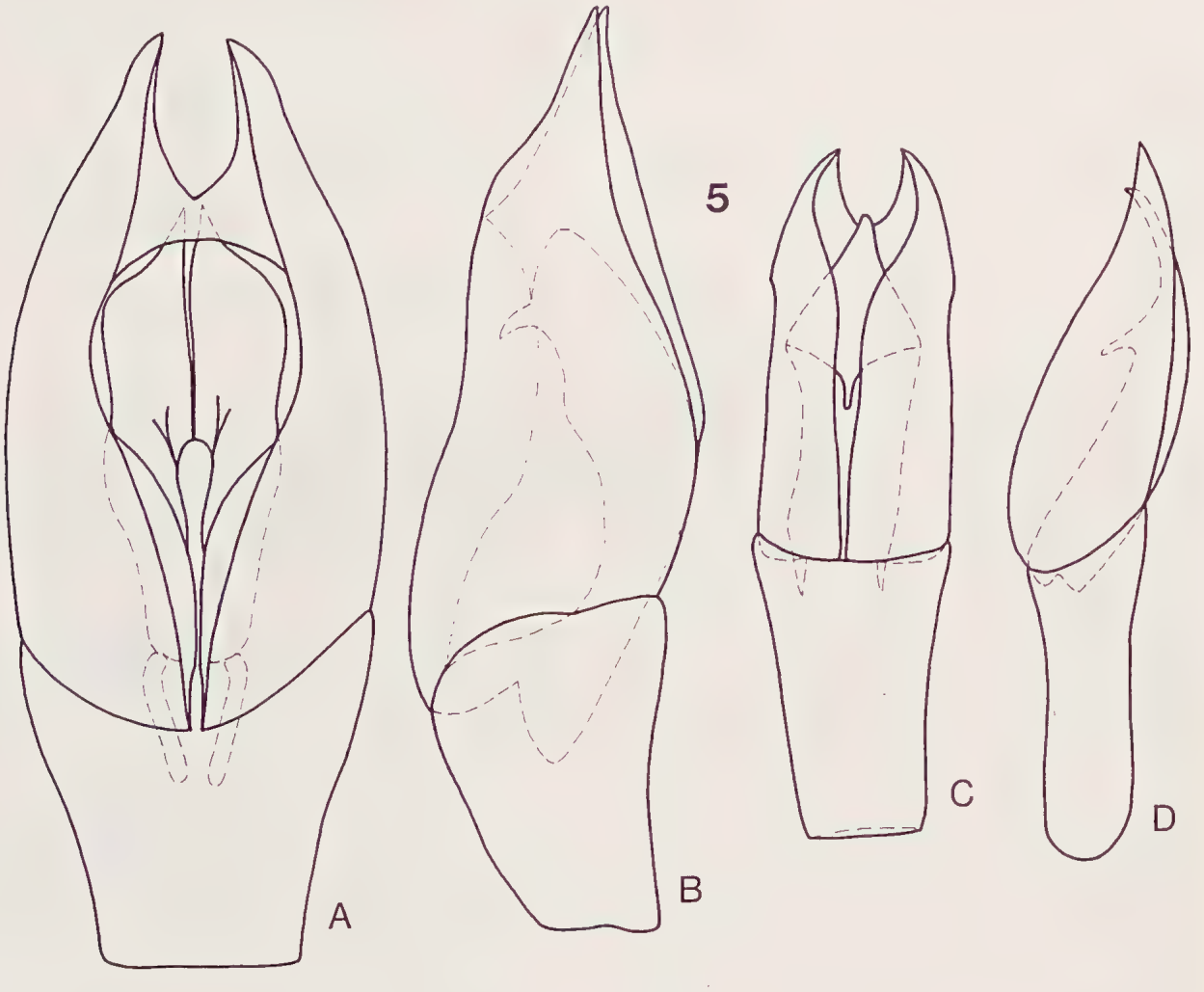
Under side dark, except hind abdominal segments, palpi, antennae, legs, and to a certain extent the prosternum. Postlabium flat, shagreened and punctured; prosternum keel-shaped. The mesosternal keel ends anteriorly in an arrow-point, scarcely protruding. Hind border of fifth abdominal sternite scarcely arched, almost straight. Palpi short; antennae much longer, legs elongated, normally shaped.

Holotype: Bishop Museum, Honolulu, Hawaii; it comes from the Northern Territory and is the only specimen known to me. Labels: Australia: N.T., Edith Ck., 2.XII.1963/J. Sedlacek Collector, Bishop Museum / E. Gentili det. 1977, *Laccobius bicaudatus* n.sp. / ♀ holotypus.

8. **Laccobius (Macrolaccobius) collium** n.sp.
(Figs. 5 a, ♂; 8)

Body length 2·3-2·4 mm; breadth 1·2-1·25 mm; oval, moderately elongated.

Dark, labium and head greenish-black, without preocular patches, micropunctured at 60 x, particularly in front of the Y-shaped suture; some larger punctures behind this suture. Labium and head large; fore margin of labium regularly arcuate; space between eyes broader than eyes as a whole.



Pronotum pale on the sides, the central patch greenish-black with uncertain borders, of the same width as space between eyes, hardly reaching fore and hind borders of pronotum at middle. Fore margin convex in middle; the hind also, but very little, on the scutellum. The whole surface smooth at 60 x, scarcely punctured. Scutellum dark, with metallic reflexes, sometimes finely punctured. Elytra testaceous, with some uncertain dark patches (one near middle of suture; another near base of elytron; a third between the others, but slightly external). Punctures darkened (except on sides and apex); the series are formed by punctures different in size, and alternately more and less regular. Sutural angle of each elytron acute, approximate to the other elytron.

Underside dark, the abdomen sometimes lighter; palpi, antennae and legs testaceous. Labium without specula; postlabium flat or lightly undulated, with some impressed punctures, near the borders lightly wrinkled. Prosternum keel-shaped; mesosternum with a tubercle on posterior half; abdomen and legs normally shaped, the claws nearly straight. Aedeagus ⅓ of body length; parameres appear to merge with each other; median lobe very complex (Fig. 5 a, b).

The typical series comes from the Northern Territory (Fig. 8). Holotype: CSIRO, Canberra; 2·3 x 1·2 mm; labels: Australia, 12° 31' S, 132° 54' E, 9 km N by E of Mudginbarry Hs., N.T., 10.VI.1973, Upton-Feehan/E. Gentili det. 1976. *Laccobius collium* n.sp./♂ Holotypus. Allotype and 4 Paratypes labelled in the same way; they are in the CSIRO and Verona Museums' Collections.

9. **Laccobius (Macrolaccobius) brittoni** n.sp. (Figs. 5 c, d; 7)

Body length 2·2-2·4 mm; breadth 1·1-1·3 mm. Closely similar to *collium;* the chief difference is in the aedeagus, which is smaller, narrower, and with a simpler median lobe (Fig. 5 c, d); the ratio aedeagus/body length is about ⅓₃. Externally, the sole difference appreciable is a greater convexity and a denser punctuation on the pronotum.

The species comes from Northern Australia (Fig. 7): Northern Territory: Bessie Springs, 16° 40' S, 135° 51' E, 8 km ESE of Cape Crawford (type locality, 4 ex., leg. M. S. Upton 26.X.1975); Nabarlek Dam, 12° 20' S, 133° 19' E, 15 km S by Nimbuwah Rock (1 ex., leg. E. G. Matthews; 2.VI.1973); Queensland: Mary Creek, 16° 33' S, 145° 12' E (2 ex., leg. Britton-Misko, at light, 4.XII.1968).

Holotype: CSIRO, Canberra; 2·2 x 1·1 mm; labels: Australia, 16° 40' S, 135° 51' E, Bessie Spring, 8 km ESE of Cape Crawford, 26.X.1975, M. S. Upton, N.T./E. Gentili det. 1976, *Laccobius brittoni* n.sp./♂ Holotypus.

Paratypes: the above list; they are in the CSIRO and Verona Museums' Collections.

THE BLACKBURN "LACCOBIUS" (NOTHYDRUS BALF.-BR., 1939, EMENDED)

Blackburn (1891) described two *"Laccobius", montanus* and *australis,* affirming that they "may be attributed to this genus . . . although they differ from the European members of it in having . . . characters . . . that may justify a new generic name". In effect, after the study of the typical females in the British Museum collections, Balfour-Browne (1939) proposed for these insects the new generic name *"Notohydrus"*, emended by d'Orchymont (1942) to *Nothydrus.* I agree with these coleopterists; the differences from the nearer genera are in my opinion great enough to separate *Nothydrus* as an independent genus.

Nothydrus has chiefly the following characters. Labium shorter than in *Laccobius,* widely excavated anteriorly; prefrons flat, long, with a straight fore margin; upper surface of the head punctured. Postlabium plate-shaped. Antennae 8-segmented (5 + 3), the fifth article nearly cupuliform, like the Cercyonini; maxillary palpi robust, nearly as long as the antennae, the fourth article longer than the third. The fore margin of the pronotum is widely excavated for the reception of the head, the corners widely rounded, the surface punctured. The prosternum is lacking a keel. The fore femora are pubescent on the whole under surface, glabrous only near the apices; the fore tarsi do not show any sexual dimorphism. Scutellum nearly equilateral. Elytra with parasutural sulci on ¾ of their length, these sulci continuing anteriorly by means of some large punctures; the elytral punctures are scattered, but showing about ten series of larger punctures, more conspicuous and engraved on the hind surface; as in *Laccobius,* the epipleura are anteriorly large, and reduced on the posterior half of the elytron. The mesosternum is tuberculate, not sharply carinate. The mid femora are pubescent like the fore. The wings are present, provided with a cantharidiform nervation. The metasternum is pubescent, slightly elevated in the middle. The hind trochanters are small, not separated at their apices from the femora; these are almost entirely pubescent, save at the apices and sometimes the hind margin; the hind tibiae are straight; the fifth metatarsal segment is shorter than the four basal segments taken together. Five abdominal segments are visible, the sixth at rest is internal. The male sexual organs are similar to those of *Anacaena* in their general pattern.

The genus differs from *Laccobius* in having five abdominal segments, a prosternum without a keel, small hind trochanters not separated from the femora, pubescent femora, sexual dimorphism absent on fore tarsi, and a sutural stria on the elytra. From *Paracymus*, it differs in having the prosternum without any keel and the mesosternum without an arrow-head shaped keel. It differs from *Anacaena* in having an elongated and depressed body form, a deeply excavated labium, conspicuous elytral series, and a cupuliform fifth antennal article. In contrast to Balfour-Browne (1939), who suggested an affinity with *Laccobius*, placing the genus *Nothydrus* at the end of the subtribe Hydrobiae, d'Orchymont (1942) suggested an affinity with *Anacaena*. The pattern of the aedeagus (basis of the tegmen pointed; aedeagus flat, with a simple trilobate structure) confirms his opinion.

Nothydrus australis (Blackburn, 1891)
(Fig. 6 a)

Blackburn, 1891 *(Laccobius);* Knisch, 1924 *(Laccobius);* Balfour-Browne, 1939 *(Notohydrus);* d'Orchymont, 1942.

Body length 2·9-3·5 mm; breadth 1·5-1·8 mm; oval elongated, less than twice as long as its width.

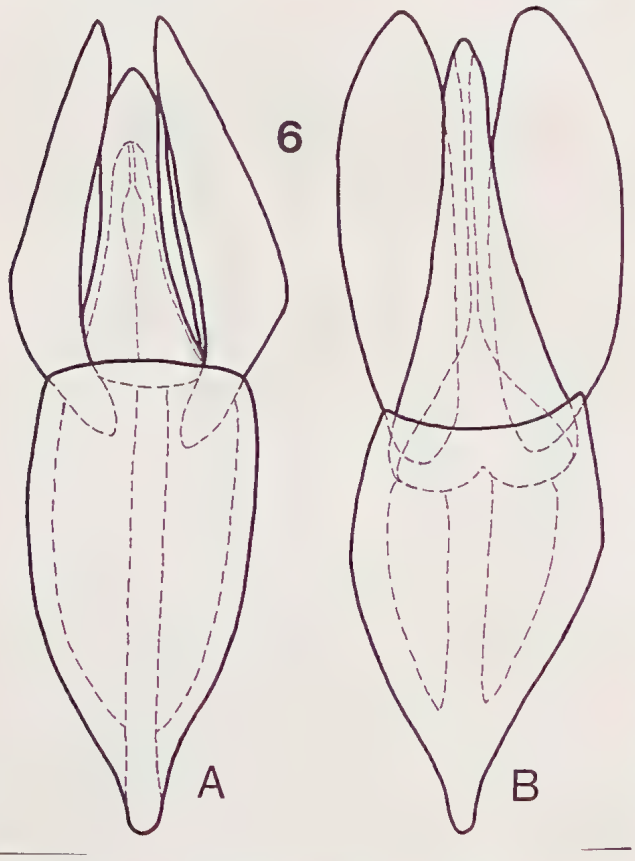


Fig. 6—A, Aedeagus of *Nothydrus australis*, Dondangadale, Victoria: frontal view; B, Aedeagus of *Nothydrus montanus*, Erica, Victoria: frontal view.

The beetle has the characters of the genus. It is enough to record here the differences from *montanus*. The dorsal colour is pale, testaceous, only the discs of the head and of the pronotum being dark. The puncturation of the head and pronotum is finer and sparser than that of the elytra, while on the elytra the puncturation of the series is quite notably distinct from that of the general surface. The sides of the pronotum are not transparent. The greatest width is at the level of the middle of the elytra. The plate of the postlabium (flat, smooth, without punctures) and the sides of the abdomen are yellowish, the remainder of the under surface is dark. The hind femora are pubescent near the fore margin. Aedeagus nearly ⅕ of the body length; tegmen longer than parameres; these are narrow and sharp at their apices like the median lobe (fig. 6 a).

Australia, Victoria: Ovens River (type locality, Blackburn, 1891); Bogong Village (1 ex., leg. A. Neboiss, 23.I.1960); Upper Nariel (6 ex., leg. A. Neboiss, 29.I.1957); Dondangadale (2 ex., leg. A. Neboiss, 11.I.1955); Marwall River (3 ex., leg. S. Trout, XII.1945); Sth. Neerim (1 ex., leg. F. E. Wilson 11.I.1941, det. A. d'Orchymont). These specimens are in the National Museum of Victoria, Melbourne, and in the Museum of Verona, Italy.

Holotype: British Museum; 3·0 × 1·5 mm; labels: T 3564 Al / Holotype / Australia, Blackburn Coll., B. M. 1910-236 / *Laccobius australis* Blackb. / *Laccobius australis* Blkb., M. E. Bacchus det. 1977, Holotype / *Nothydrus australis* Blackb., E. Gentili det. 1977.

Nothydrus montanus (Blackburn, 1891)
(Fig. 6 b)

Blackburn, 1891 *(Laccobius);* Knisch, 1924 *(Laccobius);* Balfour-Browne, 1939 *(Notohydrus);* d'Orchymont, 1942.

Body length 3·5-4·5 mm; breadth 1·9-2·3 mm; larger than *australis* but like it in shape.

The chief differences from *australis* are the following. Dorsal colour darker, blackish-brown, more shining; apart from the preocular patches, only the sides of the pronotum are clear and transparent. The upper puncturation is the same on the head, pronotum and elytra, consisting of finer and sharper punctures than in *australis*, and it includes the punctures of the series, confusing the latter with those of the interseries. The greatest width is at the level of the base of the elytra. The plate of the postlabium (flat, without punctures, but slightly alutaceous) is pale, the remaining underside is dark. Hind femora pubescent at the bases. Aedeagus nearly ⅙ of body length; tegmen long like the parameres, these larger than in *australis*, with rounded apices; the median lobe very wide at the base (Fig. 6 b).

Australia, Victoria: Victorian Mountains (type

locality, Blackburn, 1891); Bogong, High Plain (1 ex., leg. A. Neboiss, 26.I.1960); Erica (4 ex., leg. A. Neboiss, 29.I.1960); Millgrove (1 ex., leg. A. Neboiss, 26.III.1958); Cumberland Falls (1 ex., leg. A. Neboiss, 16.II.1958); Black's Spur (2 ex., leg. C. Oke, I.1934); Fern Tree Gully (1 ex., leg. C. Oke); New South Wales: Kosciusko (2 ex., leg. H. G. Carter). The specimens of this list are in the National Museum of Victoria, Melbourne, in the South Australian Museum, Adelaide, and in the Museum of Verona, Italy.

Holotype: British Museum; 3·6 × 1·85 mm; labels: Holotype / T 3563 Al. / Australia, Blackburn Coll., B. M. 1910-236 / *Laccobius montanus* Blackb. / *Laccobius montanus* Blkb., M. E. Bacchus det. 1977 Holotype / *Nothydrus montanus* Blackb. E. Gentili det. 1977.

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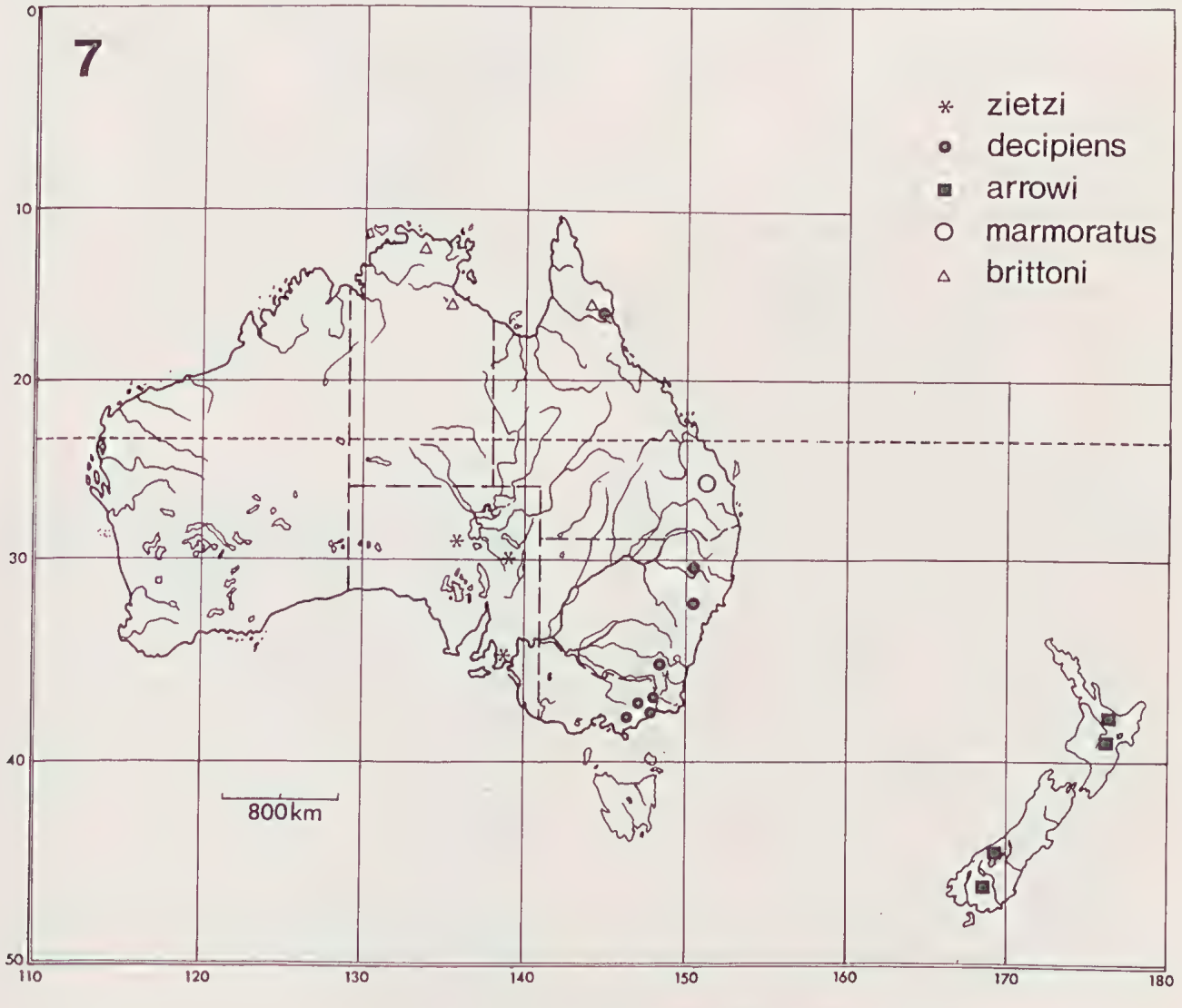

Fig. 7—Geographical distribution of *Laccobius zietzi, decipiens, arrowi, marmoratus,* and *brittoni.*

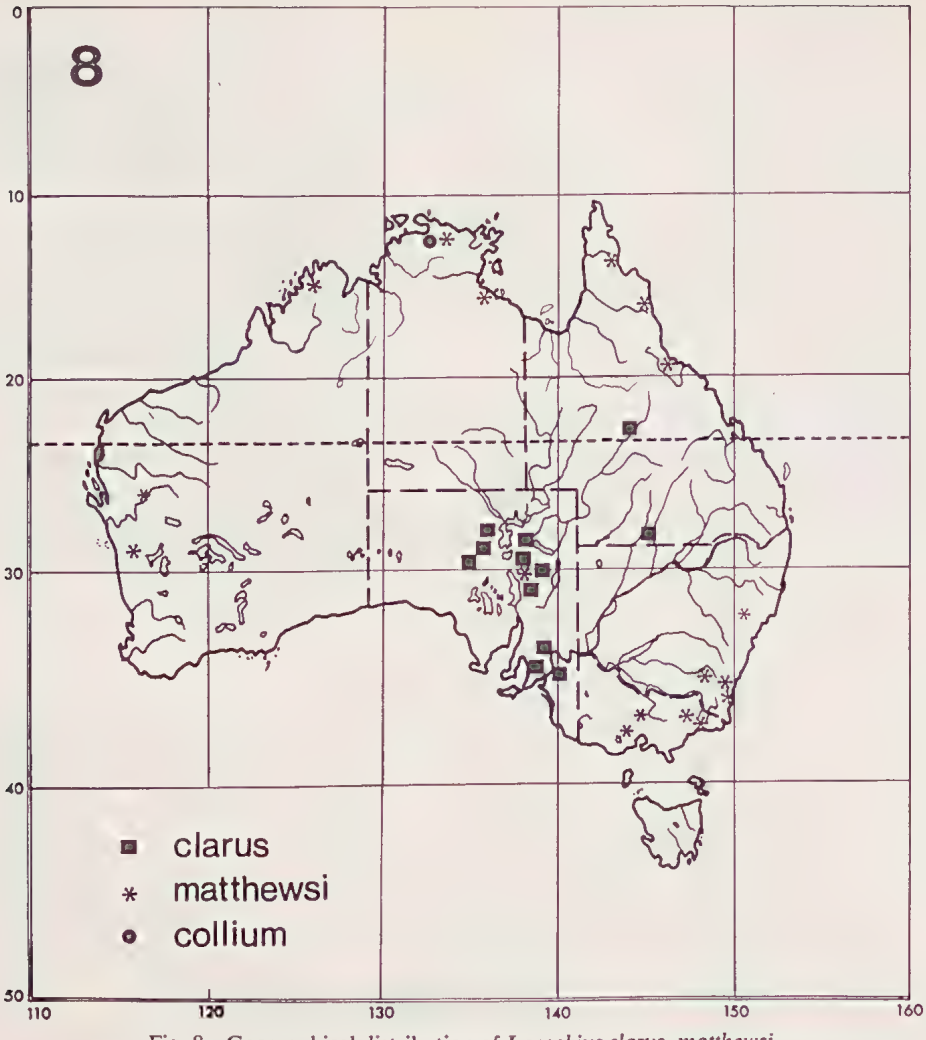

Fig. 8—Geographical distribution of *Laccobius clarus, matthewsi,* and *collium.*

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THE FABRICIAN TYPES OF THE AUSTRALIAN AND NEW ZEALAND COLEOPTERA IN THE BANKS COLLECTION AT THE BRITISH MUSEUM (NATURAL HISTORY)

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ABSTRACT

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The Banks Collection is a collection of Fabrician types housed in the British Museum (Natural History). It was presented to the British Museum in 1863 by the Linnean Society. In this paper the Australian and New Zealand Coleoptera are classified as far as possible according to their present status. This classification includes nine new synonyms and eighteen species omitted from recent catalogues. In the discussion of the species they are recorded alphabetically. The original Fabrician reference and the 1801 reference are given, together with the Junk Coleopterorum Catalogus reference where applicable, and the Zimsen reference. As far as possible known synonyms of the species are listed. The labels and condition of the types are given and in some cases comments are made as to identification and locality. Sometimes it has been found that the Fabrician locality is incorrect. There is rarely a locality label on the specimen—but is only given in the original description. In the cramped conditions on the H.M.S. *Endeavour* there must have been some mixing of material.

INTRODUCTION

In 1928 Dr. R. J. Tillyard, who was the chief of the Division of Entomology in the then recently created Australian Council of Science and Industrial Research, suggested that while I was studying in London I should examine the Australian and New Zealand species of Coleoptera in the Banks Collection located in the British Museum. This I did and received much help from G. J. Arrow, and K. G. Blair of the Museum and G. E. Bryant of the Entomological Bureau. On my return to Australia, late in 1929, I was fully occupied in establishing the Coleoptera Collection of the C.S.I.R. in Canberra. My manuscript on the Banks Collection was laid aside and only came to light again in 1976.

In the meantime specialists in various groups have studied some of the species, tracing out their present status and in some cases their synonymy. These are, as far as I have been able to ascertain, H. J. Carter (1926, 1929, 1930) on Australian Tenebrionidae, Buprestidae, and Alleculidae; P. Lepesme (1939) on Dermestidae; H. E. Hinton (1945) on Dermestidae; G. Ochs (1949) on Australian Gyrinidae; P. B. Carne (1957) on Australian Dynastinae; G. Kuschel (1969, 1970) on New Zealand Curculionoidea; E. G. Matthews (1972, 1974) on Australian Scarabaeinae; Y. Löbl (1976) on Australian species of *Scaphidium*.

The purpose of this paper is to present a list of the Fabrician Types of the Coleoptera in the Banks Collection in the British Museum (Natural Museum), for which Fabricius recorded the localities as "nova Hollandia", "nova Zelandia", and "terra Diemenii". A systematic list has been drawn up and the species classified, as far as possible, into families, sub-families, and their present generic status. It has been found that some species have been omitted from recent catalogues. This may be due to the very brief and inadequate original descriptions, which are often no more than two lines, together with the "habitat" for the locality giving only the name of the country, e.g., "nova Hollandia" and not mentioning any particular region. Sometimes the name of a collector or a collection is given, e.g., "Mus.Dom. Banks", or just "Dom.Banks". In some instances a comparison with a related species is given or, especially in his later publications, a fuller description is added.

Fabricius at first only separated the insects he studied into the large groups or orders as we now know them. Then, on the characters of the mouth parts, he classified them into genera only, not into families and sub-families although he did put them into groups according to the antennal structure. As he studied more and more specimens he realised his initial genera contained many species which could be better classified into smaller groups and so added more and more genera. Thus we find in his later publications the original generic name of the species was sometimes changed.

E. Zimsen (1964) published a book on "The Type Material of J. C. Fabricius". In this work she states where the specimens on which Fabricius based his descriptions are to be found. Fabricius did not label any particular specimen as a type and sometimes his descriptions were made from more than one specimen. S. L. Tuxén (1967: p. 8), who worked closely with Ella Zimsen, explains that from the references given by Fabricius in his original descriptions she "inferred, though it is nowhere stated explicitly in his books" that where the name of a collector or a collection is given that is where the "type specimen or specimens" are to be found, and where no such reference is given the type specimen is in his own collection, now housed in the Zoological Museum at Copenhagen. Tuxén adds, "Her work, based on this axiom, showed this to be the case . . . There may be reasons of labelling for this difficulty (choosing the type), but there is also

another reason which Fabricius himself mentions in 1803 (Tuxén 1967: pp. 9-10). In later years Fabricius himself got so confused in describing so many species (Zimsen lists 9 776), that he sometimes put one insect in two different genera or used the same name for different species. Tuxén quotes Fabricius:—"In my youth this did not easily happen, my memory was better and my eye sharper, now both are weaker . . ." It is understandable that in dealing with so many specimens mistakes occurred. Where there is only one known specimen then it can be taken as the holotype, but where there is more than one specimen later workers have sometimes selected a specimen as the lectotype and the others in the series are known as paralectotypes. Where no such study has been made the series are known as syntypes. In the late 19th century C. O. Waterhouse studied the Fabricius material in the Banks Collection and put type labels on those specimens which he was reasonably able to ascertain were the specimens to which Fabricius's description referred. Where the species is represented in the collection by only one specimen I have called it the holotype as Fabricius's reference states in "Mus. Dom. Banks". If there are two specimens I have called them syntypes according to the present day nomenclature. If one of these has a museum type-label on it, in the comments I have referred to that specimen as "type" as future workers may designate them as holo-, lecto- or syntypes. Where there was more than one specimen of a species the owner of the collection often gave Fabricius specimens for his own collection. Thus some "type material" occurs in more than one place. The references for the synonyms of each species are not given in the bibliography.

This paper brings to light 18 Fabricius species which have been overlooked or omitted from recent catalogues, records nine new synonyms, and gives a modern classification for the Australian and New Zealand species in the Banks Collection.

JOHANN CHRISTIAN FABRICIUS

Johann Christian Fabricius was born at Tønder in Denmark in 1745. He was fortunate that he was able to travel throughout Europe and England, where he had access to many museums and private collections. London became his second home. At the British Museum he met Dr. C. Solander who, like himself, had studied under Linnaeus at Uppsala. When Solander and Banks sailed on H.M.S. *Endeavour*, Fabricius returned to Copenhagen where he had been appointed a professor at the Charlottenberg Naturalickabenet. In 1771 H.M.S. *Endeavour* returned to England. From 1772-1775 Fabricius divided his time between Copenhagen and London, continuing his studies of the insects in the collections of Hunter, Drury and Banks—the latter now included the insects brought back from the voyage on the *Endeavour*. In 1775 his Systema Entomologiae was published, which consisted mainly of descriptions of insects he collected in England, or of insects he had studied in the English collections. He stated of this publication, "Entomology was at that time in its infancy". Up till then the only classification known was that of Linnaeus, who had based his classification on the wings of insects which was not satisfactory as Linnaeus himself realised. Also Linnaeus did not have sufficient specimens to make an entirely satisfactory classification. Fabricius used the mouth parts as a basis for classification. He was aware of its limitations but considered his classes were "more natural and my species were more numerous and more ably defined and the number of described genera considerably greater". Fabricius had now become the entomological authority of the day, and in his classifications introduced the concise language of the Linnaean "school" into this compartment of Natural History. He continued to travel in Europe and in England where he spent the summers of 1780-81 and again in 1787 (Tuxén 1967: p. 3). During these travels he had access to many museums and private collections. He published many systematic works on insects and in the later part of his life published monographs of the larger orders of insects. He died in 1808.

SIR JOSEPH BANKS

Joseph Banks was born in 1743 into a wealthy family. He was educated at Harrow, Eton and Oxford where Botany was one of his chief studies. Although Botany was his life interest he had an extensive knowledge of all the Natural Sciences. His house at 32 Soho Square was open to all who wished to study his collections and work in his library. His wealth enabled him to undertake and finance three voyages. The first in 1766 to Newfoundland and Labrador, the second on the *Endeavour* from 1768-1771, and the third to Iceland and Staffa. It was due to the Royal Society that he obtained permission for himself and a staff of seven, including Dr. C. Solander of the British Museum, to accompany Lieutenant (later Captain) Cook on the *Endeavour*. He was fully aware of the task he was undertaking to make collections of Natural History specimens, which would be mostly new to Science, on the long voyage ahead of him. His preparations were thorough. John Ellis F.R.S. in a letter to Linnaeus gives us the only known account of these preparations:— "No people went to sea better fitted out for the purpose of Natural History. They had got a fine library of Natural History; they have all sorts of machines for catching and preserving insects, all kinds of nets, trawls, drags and hooks for coral fishing; they even have a curious contrivance of a

telescope, by which, put into water, you can see the bottom at a great depth where it is clear. They have many cases of bottles with ground glass stoppers, of several sizes to preserve animals in spirit. They have several sorts of salts to surround the seeds, and wax both beewax and that of Myrica. Besides there are many people whose sole business is to attend them for this very purpose". He was a true scientist in that he was a keen observer and a careful recorder. All specimens collected were recorded and preserved. He was also a keen student of the ethnic races that they encountered. Banks made friends easily and throughout the three years voyage there was no friction with Cook and the crew.

The voyage of the *Endeavour* enabled the scientists to collect at Madeira, Rio de Janeiro, in the region of Cape Horn, Tahiti, round the coast of New Zealand, where Cook discovered it to be two islands not one; along the east coast of Australia landing for short periods at Botany Bay, Bustard Bay, Thirsty Bay, then for two months at Cooktown while the ship had to be repaired after running on to a reef; then sailing round Cape York, proving New Guinea to be a separate island, stopping briefly on the west of New Guinea at Cook's Bay; then on to Suva and Batavia, and home round the Cape of Good Hope with a stop at St. Helena.

The voyage was primarily undertaken to observe the transit of Venus across the sun at Tahiti. This was not successful as the instruments of those days did not make it possible to take accurate observations. However, the work of Banks and his staff, the collections and observations of Natural History and of the ethnic races they encountered, were of inestimable value. After this, scientists were always part of the personnel of the British voyages of discovery. Banks himself did not publish any papers. He did keep and file all his correspondence which showed how wide his interests were. In 1779 he was asked to give evidence before a committee of the House of Commons concerning the suitability of Botany Bay as a convict settlement. Nothing was done till 1786 when the over-crowding of the prisons made the matter urgent, and on Banks' advice plans were made and the new colony was established shortly afterwards. For some time the governors of the colony wrote to Banks for help and advice and he acted as a go-between for the Government and the colony. Banks was by then scientific adviser to the Royal Gardens at Kew and his work there made the Gardens a centre for botanical research into plants of all the colonies of the Crown, which he foresaw would be necessary for their development. Today the Gardens are still a centre for botanical research.

Unfortunately Sir Joseph Banks ended his life as an invalid and a cripple, but to the end, his interest in all around him never flagged. His papers were left to his wife's nephew, and at his death were to go to the British Museum. Through misunderstanding as to the final destination and ownership, the papers were sold at auction, many were lost or destroyed and those remaining were distributed all over the world. Fortunately for Australia many of the papers relating to Australia, including the original copy of the Journal of the Voyage of the *Endeavour*, were procured and are now in the Mitchell Library. Apart from his papers, his library and collections were left to the botanist, Robert Brown. Later via the Linnaean Society they were removed to the British Museum which ensured their preservation.

THE BANKS COLLECTION OF AUSTRALIA AND NEW ZEALAND COLEOPTERA

In a report by C. O. Waterhouse (1906: p. 580) he states that the Banks Collection "was received in the original Banksian cabinet . . . the specimens are, however, kept in the order of Fabricius' Systema Entomologiae." This is the 1775 publication. Many species in the collection were described after this date. Waterhouse adds, "Some of the species mentioned by Fabricius as being in this collection were not in it when it was received by the Museum." Recently (1979) some Banks material has been found in the Hunterian Collection in Glasgow. In correspondence with Dr. H. Brock of the University of Glasgow she writes; "There are in all over 100 specimens in the Hunterian Collection that must have come from the Cook voyages." I agree with her that Fabricius when working on both the Banks and Hunter Collections "enabled Hunter to acquire Banks duplicates." Banks was a generous man both with his money and possessions and shared them with others. Fabricius certainly added specimens from the collections he studied to his own collection. Now two of the six missing "types" from the Banks Collection, namely *Dermestes navalis* and *Lampyris australis* are found to be in the Hunterian Collection. As he worked with so many specimens it is very probable that some specimens were put back in the wrong collection. The Banks Collection contains over 3 000 insects in all. The Systema Eleutheratorum is Fabricius's record of the Coleoptera he described.

The Banks Collection of Coleoptera is now arranged in the order given by Fabricius in the Systema Eleutheratorum, 1801, except for one specimen which was omitted from the Eleutheratorum, and was found by E. Zimsen (1964) among the unnamed specimens. It was then added at the end of the named specimens in the collection.

Where they exist, the references given for each species are:—

1. The original reference.
2. The Systema Eleutheratorum.
3. Junk's Coleopterorum Catalogus.
4. The reference in "The Type Material of J. C. Fabricius" by E. Zimsen.
5. The reference of a recent reviser of the group.

The species with the original reference in Systema Entomologiae, 1775, and four Curculionoidea from New Zealand with the original reference in the Species Insectorum, 1781, were collected during the voyage of the *Endeavour*. G. Kuschel (1920: p. 192) states that "the more spectacular weevils" were described first in 1775 and "the remainder" were described later. The species with the original reference in the Mantissa Insectorum, 1787, were collected by D. Nelson, who was sent by Banks on Captain Cook's third voyage on H.M.S. *Discovery*.

After the return of H.M.S. *Endeavour* many more voyages of discovery were made. Banks himself only made one more voyage after his return and that was to Iceland and the Shetland Islands. However, when opportunity offered, he sent out men at his own expense or from the Royal Gardens at Kew to collect for him and for the Gardens (Maiden 1909: p. 124). David Nelson was one of these collectors.

In this paper 131 Fabrician specific names are listed, ten of these are synonyms as Fabricius renamed those species in his later publications for one reason or another. Of the remaining 121:—

i. Seventy-nine species are recorded by Fabricius from "nova Hollandia". The locality of seven of these were erroneously recorded, three are probably from the East Indies, and four from New Zealand. As G. Kuschel (1970: p. 191) points out, there must have been some mixing of material on H.M.S. *Endeavour*.

ii. Thirty-two species are listed from "nova Zelandia". Of these, the locality of one is doubtful, and one erroneously recorded from "Brasilia" has been included (Kuschel 1970: p. 199).

iii. Eight species are recorded from "terra Diemenii" one of which is labelled Kerguelen.

iv. Two are recorded as being from both "nova Hollandia et Zelandia".

In each case an exact copy of the Fabrician label, which is in his own handwriting, has been given. Sometimes the label is no more than a scrap of paper, but according to Zimsen (1964: p. 10) Fabricius in his own collection used "a small scrap of paper on which was written the name of the species, never mention of the genus". In the Banks Collection, however, the genus is usually given, but very rarely the locality or name of a collector. The Fabrician labels in this Collection are usually written in two lines, the upper one giving the name and the lower one the reference. In some cases the reference is the number only of the species in the genus being described, with no page reference. This would indicate that the label was attached when the species was described and before publication; where the page also is given would denote that the label was added after publication. In the introduction of both his publications, Species Insectorum, 1781, and Mantissa Insectorum, 1787, it is stated that these works contain descriptions of species studied in "Anglia" (England). These descriptions were not only of new species but also fuller descriptions of some species already described in the Systema Entomologiae, 1775. When compiling his Species Insectorum, 1781, he says "My system of Insects gained ground considerably, as well by the more exact definition of the species, as by the addition of a considerable number of genera." In doing so Fabricius must have changed the labels on some of the species he redescribed, so we find references to a later publication instead of the original one, and sometimes a change of the generic name. As more and more specimens were examined he realised his classification required further divisions. Therefore, sometimes the BMNH label has a different genus to the original one, in fact the genus for the species as given in Systema Eleutheratorum. It is probable that the BMNH label was written when the collection was arranged according to the order in that publication. A few specimens also have a BMNH register number 63-46 on a small blue disc. The Museum name-labels are not attached to the specimen but are pinned below it, except for C. O. Waterhouse's type-labels. Kuschel (1970) did not add any holotype or lectotype labels when he studied the New Zealand Curculionoidea in the collection. The specimens are usually pinned through the right elytron and in most cases the pin has been glued on the ventral surface, often obliterating the structures.

In the discussion of the species they are listed in alphabetical order according to the specific name. Known synonyms are listed. The numerous varieties of the chrysomelids are not listed as I believe that there is much work to be done on the separation of these varieties. The localities given are those published by Fabricius, but corrections to these localities have sometimes had to be made.

The following list of places visited by Cook around the coasts of New Zealand and Australia will give some indication where the type specimens were collected. A. Musgrave (1954: p. 232-7) points out that when the *Endeavour* was sailing up the coast of

Australia it was late in the season for collecting insects at Botany Bay, so probably most of the insects from Australia would have been collected at Endeavour River (Cooktown). However, Banks' journal does record that collecting was done at both Bustard and Thirsty Bays.

Round the coast of New Zealand:—

1769 9-10 October at Poverty Bay
20 October at Anaura Bay
23-29 October at Tolaga Bay
4-15 November at Mercury Bay
20 November at Waihou (Thames) River
29 November- 5 December at Bay of Islands

1770 16 January- 6 February at Ship Cove, Queen Charlotte Sound
27-30 March at D'Urville Island
31 March left New Zealand waters and sailed to Australia
27 April- 6 May at Botany Bay
23-24 May at Bustard Bay
29-31 May at Thirsty Bay
16 July- 4 August at Endeavour River (Cooktown)
3 September at Cooks' Bay, New Guinea
18-21 September at Savu (Sawu) Indonesia
10-26 October at Batavia (Jakarta) Java

1771 4-14 January at Princes Island

1773 13 May- 7 June at Ship Cove, Queen Charlotte Sound, New Zealand
3-25 November at Ship Cove, Queen Charlotte Sound, New Zealand
23 March- 11 May at Dusky Sound, New Zealand

1776-77 24 December- 7 January at Kerguelen's Land
26-30 January at Adventure Bay, Tasmania
12-25 February at Ship Cove, Queen Charlotte Sound, New Zealand

The letters BMNH are used to denote the British Museum (Natural History)

CLASSIFICATION OF THE AUSTRALIAN AND NEW ZEALAND COLEOPTERA IN THE BANKS COLLECTION

This classification follows that of E. Britton in "Insects of Australia" published by the C.S.I.R.O. (1970: pp. 517-8).

New synonyms, and those species Fabricius renamed in later publications, now regarded as synonyms, are given in this classification. A full list of synonyms is given under the heading of each species.

The original generic names are in parentheses.

*Denotes that the species has been omitted from recent catalogues.

†Denotes a new synonym.

FAMILY CARABIDAE
sub-family Scaritinae
Laccopterum cyaneum (F.) *(Scarites)*
sub-family Cicindelinae
Cicindela tuberculata F.

FAMILY DYTISCIDAE
Platynectes decempunctatus (F.) *(Dytiscus)*

FAMILY GYRINIDAE
Dineutes australis (F.) *(Gyrinus)*

FAMILY HISTERIDAE
Saprinus cyaneus (F.) *(Hister)*
* *Saprinus detritus* (F.) *(Hister)*

FAMILY SCAPHIDIIDAE
Scaphidium quadripustulatum (F.) *(Sphaeridium)*

FAMILY STAPHYLINIDAE
Creophilus oculatus (F.) *(Staphylinus)*
Creophilus erythrocephalus (F.) *(Staphylinus)*

FAMILY LUCANIDAE
Lissotes cancroides (F.) *(Lucanus)*

FAMILY SCARABAEIDAE
sub-family Scarabaeinae
Onthophagus quadripustulatus (F.) ♂ *(Scarabaeus)*
= *O. bipustulatus* (F.) *(Scarabaeus)* ♀
Tesserodon novaehollandiae (F.) *(Scarabaeus)*
= *T. hollandiae* (F.) *(Scarabaeus)*
sub-family Cetoniinae
Glycyphana stolata (F.) *(Cetonia)*
= *G. fasciata* (F.) *(Cetonia)*
sub-family Dynastinae
Haploscapanes barbarossa (F.) *(Scarabaeus)*
Pericoptus truncatus (F.) *(Scarabaeus)*
sub-family Melolonthinae
Calonota festiva (F.) *(Melolontha)*
C. festiva var. *laeta* (F.) *(Melolontha)*
Chlorochiton suturalis (F.) *(Melolontha)*
Liparetrus sylvicolus (F.) *(Melolontha)*
Liparetus monticolus (F.) *(Melolontha)*
sub-family Rutelinae
Repsimus aeneus (F.) *(Melolontha)*

FAMILY PSEPHENIDAE
* *Sclerocyphon collaris* (F.) *(Tritoma)*
† = *S. bicolor* Carter

FAMILY BUPRESTIDAE
sub-family Buprestinae
Cisseis s.g. *Neospades cruciata* (F.) *(Buprestis)*

sub-family Chalcophorinae
Cyphogastra farinosa (F.) *(Buprestis)*

FAMILY RHIPICERIDAE
Rhipicera mystacina (F.) *(Hispa)*

FAMILY LAMPYRIDAE
Luciola australis (F.) *(Lampyris)* in Glasgow

FAMILY MELYRIDAE (DASYTIDAE)
Dasytes minutus (F.) *(anobium)*
† = *D. subcyaneus* Broun

FAMILY DERMESTIDAE
Dermestes carnivorus F. *(carniforus* F.)
Dermestes felinus F. is a synonym of *D. ater* Degeer

FAMILY BOSTRYCHIDAE
Bostrychopsis jesuita (F.) *(Apate)*
Dinoderus minutus (F.) *(Apate)* Type lost

FAMILY LYCIDAE
Trichalus serraticornis (F.) *(Lycus)*

FAMILY CLERIDAE
Eunstalis porcata (F.) *(Notoxus)*
Phymatophaea violacea (F.) *(Notoxus)*
† = *Balcus niger* Sharp

FAMILY NITIDULIDAE
Macroura abbreviata (F.) *(Nitidula)*

FAMILY PHYCOSECIDAE
* *Phycosecis limbatus* (F.) *(Dermestes)*

FAMILY COCCINELLIDAE
Coccinella leonina F.
Coelophora inaequalis (F.) *(Coccinella)*
Coelophora novemmaculata (F.) *(Coccinella)*
= *Coelophora novempunctata* (F.) *(Coccinella)*
Epilachna guttato-pustulata (F.) *(Coccinella)*
Veranis striola (F.) *(Coccinella)*
= *V. lineola* (F.) *(Coccinella)*

FAMILY COLYDIIDAE
Ulonotus scaber (F.) *(Dermestes)*
† = *U. integer* Sharp

FAMILY TENEBRIONIDAE
sub-family Ulominae
Adelium porculatum (F.) *(Calosoma)*
=*A. porcatus* (F.) *(Carabus)*
* *Alphitobius laevigatus* (F.) *(Opatrum)*
Celibe laevicollis (F.) *(Silpha)*
Dermestes navalis (F.) is a synonym of *Triboloides* (Blair 1913) *ferrugineus* (F.)
* *Uloma sanguinipes* (F.) *(Tenebrio)*
sub-family Amarygminae
Amarygmus bicolor (F.) *(Erotylus)*
* *Amarygmus morio* (F.) *(Erotylus)*
Chalcopterus amethystinus (F.) *(Erotylus)*
Chalcopterus cupreus (F.) *(Erotylus)*
* = *Ch. setosus* Blackburn
Chalcopterus smaragdulus (F.) *(Erotylus)*

FAMILY LAGRIIDAE
Lagria tomentosa F.

FAMILY ALLECULIDAE
* *Homotrysis rufipes* (F.) *(Helops)*

FAMILY OEDEMERIDAE
* *Dohrnia tristis* (F.) *(Necydalis)*
Selenopalpus cyaneus (F.) *(Lagria)*
† = *S. subviridus* White
Sessinia lineata (F.) *(Lagria)*

FAMILY CERAMBYCIDAE
sub-family Prioninae
Toxeutus arcuatus (F.) *(Prionus)*
sub-family Lamiinae
Depsages solandri (F.) *(Lamia)*
Hybolasius cristus (F.) *(Lamia)*
Xylotoles griseus (F.) *(Saperda)*
Xylotoles lynceus (F.) *(Saperda)*
sub-family Cerambycinae
Coptomma variegata (F.) *(Callidium)*
Hesthesis variegata (F.) *(Leptura)* Type lost
Navomorpha lineata (F.) *(Callidium)*
Navomorpha sulcata (F.) *(Callidium)*
Oemona hirta (F.) ♂ *(Saperda)*
= *O. villosa* (F.) ♀ *(Saperda)*
Pachydissus obscurus (F.) *(Callidium)*
Phoracantha semipunctata (F.) *(Stenocorus)*
Zorion minuta (F.) *(Callidium)*
Lamia bidens F. Present status unknown as type missing

FAMILY CHRYSOMELIDAE
sub-family Cassidinae
Aspidomorpha deusta (F.) *(Cassida)*
Aspidomorpha interrupta (F.) *(Cassida)*
sub-family Chrysomelinae
Calomela crassicornis (F.) *(Chrysomela)*
Chalcolampra octodecimguttata (F.) *(Chrysomela)*
Paropsis s.g. *Chrysophtharta detrita* (F.) *(Coccinella)*
† = *P. laesa Germ.*
Paropsisterna morio (F.) *(Chrysomela)*
Phyllocharis cyanicornis (F.) *(Chrysomela)*
Phyllocharis cyanipes (F.) *(Chrysomela)*
Phyllocharis nigricornis (F.) *(Chrysomela)*
sub-family Criocerinae
Crioceris nigripes F.
Lema bifasciata (F.) *(Crioceris)*
Lema oculata (F.) *(Crioceris)*
Lema unifasciata (F.) *(Crioceris)*

sub-family Eumolpinae
Eucolaspsis brunnea (F.) *(Chrysomela)*
Rhyparida didyma (F.) *(Cryptocephalus)*
sub-family Galerucinae
* *Monolepta cyanocephala* (F.) *(Crioceris)*
† = *M. antennalis Lea*
Synodita melanocephala (F.) *(Crioceris)*
sub-family Halticinae
Licyllus 4-punctata (F.) *(Galleruca)*
= *Altica albicollis* F.

FAMILY ANTHRIBIDAE
Phloeobius griseus (F.) *(Anthribus)* Type missing
= *Ptinus gigas* F.

FAMILY BELIDAE
Agathinus tridens (F.) *(Curculio)*
Belus semipunctatus (F.) *(Curculio)*

FAMILY BRENTHIDAE
Lasiorrhynchus barbicornis (F.) *(Curculio)*
= *Curculio assimilis* F.

FAMILY CURCULIONIDAE
sub-family Aterpinae
Aterpus cultratus (F.) *(Curculio)*
Chrysolopus spectabilis (F.) *(Curculio)*
sub-family Brachyderinae
Protomus scutellaris (F.) *(Curculio)*
sub-family Cossoninae
* *Cossonideus lineolus* (F.) *(Curculio)*
sub-family Cryptorrhynchinae
Euthyrhinus meditabundus (F.) *(Curculio)*
Omydaus luridus (F.) *(Curculio)*
* *Tentegia stupida* (F.) *(Curculio)*
= *Rhynchaeus strepidus* F.
† = *T. ingrata Faust*
Curculio cruciatus F. Present status unknown
† = *Acalles doriae Pasc.*
sub-family Curculioninae
Curculio amoenus F.
Orthorrhinus cylindrirostris (F.) *(Curculio)*
sub-family Erirrhininae
Nyxtes bidens (F.) *(Curculio)*
Stephanorrhychus attelaboides (F.) *(Curculio)*
Tysius bicornis (F.) *(Curculio)*
sub-family Haplonychinae
* *Haplonyx haemorrhoidalis* (F.) *(Curculio)*
sub-family Leptopiinae
Catoptes interruptus (F.) *(Curculio)*
Leptopius clavus (F.) *(Curculio)*
Leptopius quadridens (F.) *(Curculio)*
Leptopius tribulus (F.) *(Curculio)*
Stenocorynus crenulatus (F.) *(Curculio)*
sub-family Otiorrhynchinae
* *Oribius adspersus* (F.) *(Curculio)*
sub-family Rhadinosominae
Rhadinomus acuminatus (F.) *(Curculio)*
sub-family Rhynchophorinae
Curculio bituberculatus F. is a synonym of *Sitophilus oryzae* Linné
sub-family Rhyparosominae
* *Cecyropa modesta* (F.) *(Curculio)*

The present status of the following species has not yet been determined:—
* *Rhynchaenus curvirostris* F. *(Curculio)*
* *Rhynchaenus exclamationis* F. *(Curculio)*

DISCUSSION OF SPECIES

ABBREVIATA, Nitidula

Fabricius 1781, p. 91, n. 3
Junk's Catal. 1913, 15, 56, p. 155 *(Aethina)*
Zimsen 1964, p. 81, n. 1138

Holotype labels:
i. Fabricius "Nitidula abbreviata Fabr. Spec. Ins. n. 3"
ii. BMNH "Nitidula abbreviata"

Locality: "nova Zelandia". It is doubtful that this locality is correct.

Current status: *Macroura abbreviata* (F.): Nitidulidae.

Comment: Except for the mesothoracic legs, most of which are missing, the specimen is in fairly good condition.

This species belongs to the genus *Macroura* and not to the genus *Aethina* in which it has previously been placed. The genus *Macroura* is represented by species from India, East Indies, Australia and New Guinea. It is, therefore, possible that if the locality New Zealand is incorrect that it should be one of the above localities where Banks collected. The locality New Zealand has been queried by Broun (1880: p. 171) who stated "I have not seen any insect agreeing with Fabricius's description", also by Sharp (1891: p. 350) and by Grouvelle (1912: p. 398). In Grouvelle's table of the genus (1912: p. 574), it is very close to *M. javanica* Grouv. and *M. orientalis* Nictur.

ACUMINATUS, Curculio

Fabricius 1775, p. 152, n. 132; 1801, 2, p. 535, n. 168
Junk's Catal. 1937, 28, 154 p. 1 *(Rhadinosomus)*
Zimsen 1964, p. 219, n. 3781
Kuschel 1970, p. 203

Lectotype (Kuschel) labels:
i. Fabricius "Curc. Acuminatus Fab. Entom. p. 152 n. 132"

ii. BMNH "Curculio acuminatus", "Type"

Locality: "nova Zelandia"

Current status: *Rhadinosomus acuminatus* (F.): Curculionidae, Rhadinosominae.

Comment: Lectotype is a male. It is very dirty and in poor condition, pinned through left elytron part of which is missing, right elytron and left meta-thoracic leg are also missing. There is a second male specimen, a paralectotype, which is very badly damaged, head, prothorax and right metathoracic leg are missing.

Broun (1880: p. 430), following Lacordaire (1866: p. 63) attributed this species to Schönherr, since then the correction has been made. Kuschel designated the lectotype.

ADSPERSUS, Curculio

Fabricius 1775, p. 149, n. 118; 1801, 2, p. 529, n. 131.
Zimsen 1964, p. 217, n. 3752.

Holotype labels:

i. Fabricius "Curc. Adspersus Fab. Sp. Ins. n. 165.
ii. BMNH "Curculio adspersus".

Locality: "nova Hollandia". This species may possibly be from New Guinea or the East Indies.

Current status: *Oribius adspersus* (F.) Curculionidae, Otiorrhynchinae.

Comment: The holotype is in poor condition, head and prothorax have been broken off and glued on to the rest of body; left antenna, tarsi of prothoracic legs, both mesothoracic legs and right metathoracic leg are missing. C.O. Waterhouse did not identify this specimen as a "type". There has been a great deal of confusion in the literature about this species.

Zimsen records three specimens under the name *Curculio adspersus*, namely the numbers 3473, 3638, and 3752.

Number 3638:—The type is recorded as "in Cajenne Dom.V.Rohr" with the reference Mant. Ins. 1, p. 106. It is listed in Junk's catalogue as *Ileomus mucoreus* L. This species does not concern the Banks Collection.

Number 3473:—This was named by Fabricius as *Rhychaenus pollux*, which is now recorded by both Zimsen, and Csiki in Junk's catalogue 1934, 29, 137, 28 as a synonym of *Hypera (Erirhinomorphus) adspersus* (F.). This is not the species in the Banks Collection and should not be known by the specific name of *adspersus* as it is a junior homonym, but by the name given by Fabricius in 1801, 2, p. 457, n. 94, namely *R. pollux*.

Number 3752:—*Curculio adspersus* F. is recorded by Zimsen and as "in nova Hollandia in Dom. Banks—London 1 specimen", and gives the original reference of 1775. This species is not listed by Csiki in Junk's catalogue, but he does give two references, namely Systema Eleutheratorum 2, 1801, p. 529, n. 131, and Herbst. Nat. Ins. Kaf. 6, 1795, p. 258 for the species *H. (Erirhinomorphus) adspersus* (F.) which is incorrect. These two references are for the Fabrician species *Oribius adspersus* (F.), number 3752 in Zimsen. It was classified into the genus *Oribius* by R. T. Thompson of the BMNH (pers. comm.). *O. adspersus* (F.) is the senior homonym. The other two species which Fabricius names *Curculio adspersus* were renamed by him in Syst. El. as *Rhynchaenus pollux* and *Lixius roreus*, and these specific names should now be used for them. *L. roreus* F. is a synonym of *Ileomus mucoreus* L.

AENEA, Melolontha

Fabricius 1775, p. 34, n. 11; 1801, 2, p. 166, n. 30
aeratus Linne 1790, p. 1570 *(Scarabaeus)*
purpureipes Macl. 1871, p. 197 *(Repsimus).*
Junk's Catal. Suppl. 66 p. 285 *(Repsimus).*
Zimsen 1964, p. 144, n. 2360.
Carne 1958, p. 178-9.

Holotype labels:

i. Fabricius "Melol. aenea Fabr. Sp. Ins. n. 14".
ii. BMNH "Melolontha Aenea", "Type".

Locality: "nova Hollandia".

Current status: *Repsimus aeneus* (F.): Scarabaeidae, Ruterlinae.

Comment: The condition of the holotype is good, except that the mouth parts are covered with dried mycelial hyphae. This species is the type of the genus *Repsimus*. The reference on the label is not the original reference. This probably accounts for the fact that Fabricius would have re-examined this species before publishing Spec. Ins. 1781 and when compiling this list put this reference on the specimen before actual publication as there is no page reference given. Carne (idem) discusses the synonymy of this species in full.

ALBICOLLIS F., Altica

See *QUADRIPUNCTATA F., Galleruca*

A. albicollis F. is the junior homonym.

AMETHYSTINUS, Erotylus

Fabricius 1775, p. 124, n. 7; 1801, 2, p. 13, n. 6 *(Cnodulon)*
Junk's Catal. 1911, 18, 28, p. 579 *(Chalcopterus)*
Zimsen 1964, p. 116, n. 1806

Holotype labels:

i. Fabricius "Erot. Amethystinus Fab. Entom. p. 124 n. 7"

ii. BMNH "Cnodulon amethystinus", "Type"

Locality: "nova Hollandia"

Current status: *Chalcopterus amethystinus* (F.): Tenebrionidae, Amarygminae

Comment: The condition of the holotype is good, though the head is retracted somewhat into the prothorax, parts of both antennae are missing.

The spelling in the 1775 reference is *Erotylus amethystines* though on the label the specific name is spelt *amethystinus*. So the ending "es" is probably a misprint.

Blair (1914: p. 489) studied this species in relation to the specimens identified by Blackburn and Carter as *Ch. amethystinus* (F.). He points out the differences between these specimens and the Fabrician type.

"1. In the type, the legs are entirely black, in the other specimens the femora is red and sometimes there are traces of red colouration on the tibiae.

2. In the type there is a small but distinct depression in the centre of each half of the prothorax, this is absent in the other specimens.

3. The anterior margin of the prothorax is slightly sinuate in the type but not so in the other specimens.

4. Punctures of the elytra are heavier in the type than in the other specimens."

Blair considered that the Fabrician species is nearest to *Ch. pulcher* Blkb. but is "not identical with it". In his opinion the specimens identified by Blackburn and Carter (1913: p. 10) as *Ch. amethystinus* F. are not the Fabrician species.

This is another species Fabricius reclassified in his later publications.

AMOENUS, Curculio

Fabricius 1775, p. 142, n. 81; 1801, 2, p. 489, n. 239 *(Rhynchaenus)*
Junk's Catal. 1923, 29, 123, p. 23
Zimsen 1964, p. 208, n. 3582

Holotype labels:

i. Fabricius "Curc. Amoenus Fabr. S. Ent. p. 142, n. 81"

ii. BMNH "Rhynchaenus amoenus", "Type"

Locality: "nova Hollandia"

Current status: *Curculio amoenus* F.: Curculionidae, Curculioninae.

Comment: Holotype is in good condition, all structures are complete. At one time this species was placed in the genus *Balaninus* but is now back in its original genus *Curculio*.

ARCUATUS, Prionus

Fabricius 1787, 1, p. 129, n. 9; 1801, 2, p. 259, n. 10
curvus Gmel. 1789, p. 1817. After McKeown 1947
Junk's Catal. 1913, 22, 52, p. 38
Zimsen 1964, p. 163, n. 2717

Holotype labels:

i. Fabricius "Prionus Arcuatus v. Diem. land Nelson Fabr. Mss".

ii. Fabricius "Prionus arcuatus Fabr. Mant. Ins. n. 9"

iii. BMNH "Prionus arcuatus", "Type"

Locality: "Terra Diemenii"

Current status: *Toxeutes arcuatus* (F.): Cerambycidae, Prioninae.

Comment: Holotype has been pinned twice, now through the right elytron, previously through the prothorax; terminal joints of left antenna and some tarsi of mesothoracic legs are missing.

Lameere (1904 p. 24) studied the holotype and gives a detailed description of it.

The name Nelson on the label, is that of the collector who sailed with Cook on his third voyage, and collected at Adventure Bay, Tasmania.

ASSIMILIS, Curculio

Fabricius 1775, p. 134, n. 42; 1801, 2 p. 546, n. 3 *(Brentus)*
Junk's Catal. 1927, 26, 89, p. 58 *(Lasiorhynchus)*
Zimsen 1964, p. 221, n. 3833
Kuschel 1970, p. 194

Lectotype (Kuschel) label:

i. Fabricius "Brent. Assimilis Fabr. M. Ins. n. 9"

ii. BMNH "Brentus assimilis", "Type"

Locality: "nova Zelandia"

Current status: synonym of *Lasiorrhynchus barbaricornis* (F.)

Comments: "Type" is a female, pinned through left elytron which has been glued on to specimen. Otherwise specimen is in good condition, except for terminal joints of both antennae which are missing. The reference number 9 on the label is incorrect, it should be number 2. Kuschel (idem.) designates this specimen as the lectotype and the specimen in Fabricius's own collection as a paralectotype.

ATTELABOIDES, Curculio

Fabricius 1775, p. 156, n. 162; 1801, 2, p. 545, n. 227
osculator Broun 1909, p. 134
Junk's Catal. 1934, 28, 140, p. 81 *(Stephanorrhynchus)*

Zimsen 1964, p. 221, n. 3832
Kuschel 1970, p. 199

Holotype labels:
i. Fabricius "Curc. attelaboides Fab. Entom. 156 n. 152
ii. BMNH "Curculio attelaboides"

Locality: "Brasilia". This locality is incorrect. It is a New Zealand species.

Current status: *Stephanorhynchus attelaboides* (F.) Curculionidae, Erirrhininae

Comment: Holotype is a female. This species is endemic to New Zealand and was identified in the Collection by Kuschel (1970; p. 191) as being erroneously recorded from Brazil. Kuschel (1970: p. 199) gives a key to the indentification of this species and its closely related species.

AUSTRALIS, Gyrinus

Fabricius 1775, p. 235, n. 2; 1801, 1, p. 275, n. 3
rufipes F. 1801, 1, p. 276, n. 13
dentipennis Macl. 1825, p. 30
limbatus Macl. 1825, p. 30
iridus Hope 1842, p. 428
leucopoda Montr. 1860, p. 245 *(Dineutus)*
janthinus Reg., 1882, p. 421 *(Dineutes)*
dentatus Suffr. 1842, p. 256 *(Dineutes)*
Leucopus Montr. 1860, p. 245 *(Dineutes)*

Junk's Catal. 1910, 4, 21, p. 4 *(Dineutes)*
Zimsen 1964, p. 70, n. 927
Ochs 1949, p. 192

Holotype labels:
i. Fabricius "australis"
ii. BMNH "Gyrinus australis" museum register number 63-46.

Locality: "in novae Hollandiae aquis"

Current status: *Dineutus australis* (F.); Gyrinidae.

Comment: The holotype has been broken between the meso and metathorax and then glued together. The full list of synonyms and literature concerning this species is given by Ochs (idem.). Fabricius described the female of this species at a later date under the name of *G. rufipes* F. which is now a synonym, the type of which is in "Dom Billardiae". *D. dentatus* Suffr and *D. leucopus* Montr. are not listed by Ochs as synonyms as they are not Australian species.

AUSTRALIS, Lampyris

Fabricius 1775, p. 201, n. 11; 1801, 2, p. 104, n. 23
Junk's Catal. Suppl. 1966, 9, p. 99 *(Luciola)*
Zimsen 1964, p. 133, n. 2141

Holotype is missing from the Collection. "Type" has recently been found in the Hunterian Collection in Glasgow.

Locality: "nova Hollandia"

Current status: *Luciola australis* (F.) Lampyridae.

Comment: In Gemminger et Harold Catalogue this species is recorded under the name *Luciola australis* (F.) and the locality is erroneously given as "Nov. Island" (New Ireland). Boisduval (1835; p. 125) gives the same locality. However, Masters (p. 312) and McDermot in Junk's Suppl (idem.) records the Fabrician locality, "Australia". Masters records two synonyms *L. guerini* Laporte and *L. nigripennis* Latr. McDermot states that *L. guerini* Laporte is from New Guinea and is not a synonym of *L. australis* (F.). *L. nigripennis* Latr is not listed by McDermot and Lea (1909: p.108) regards *L. nigripennis* Latr as merely a "catalogue name". Therefore there is no recognised synonym of *L. australis* (F.).

BARBAROSSA, Scarabaeus

Fabricius 1775, p. 12, n. 35; 1801, 1, p. 47 *(Geotrupes)*
var *similis* Prell 1934, p. 57.
Junk's Catal. 1937, 21, 156, p. 93 *(Haploscapanes)*
Zimsen 1964, p. 22, n. 28 *(Geotrupes)*

Carne 1957, p. 190

Syntypes labels:
i. Fabricius "Scarab. Barbarossa" Fabr. Sp Ins. No. 41.
ii. BMNH "Geotrupes barbarossa"

Locality: "Nova Hollandia"

Current status: *Haploscapanes barbarossa* (F.).: Scarabaeidae, Dynastinae.

Comment: There are two specimens, a male and female. The condition of the male is fair; only two basal joints of the antennae are present and the terminal joints of the left labial palp and most of the tarsi are missing. The female is an exceptionally large specimen and is in good condition. The reference on the label is the 1781 reference so Fabricius must have re-examined this specimen in 1780-1.

BARBICORNIS, Curculio

Fabricius 1775, p. 134, n. 41; 1801, 2, p. 545, n. 1 *(Brentus)*
assimilis F. 1775, p. 134
Junk's Catal. 1927, 26, 89, p. 58 *(Lasiorrhynchus)*
Zimsen 1964, p. 221, n. 3833
Kuschel 1970, p. 193-5

Lectotype (Kuschel) labels:
i. Fabricius "Brentus Barbicornis Fabr.

Mant. Ins. n. 1"
ii. BMNH "Brentus barbicornis", "Type"

Locality: "nova Zelandia"

Current status: *Lasiorrhynchus barbicornis* (F.): Brenthidae

Comments: There are two specimens both males. The "type" specimen designated by Kuschel as the lectotype is very dirty and terminal joints of left antenna are missing. In the 2nd specimen, a male, a paralectotype (Kuschel) head is missing. Broun (1880: p. 543) notes that there is great variation in length of this species. The reference on the label indicates that Fabricius must have re-examined this species after the original 1775 publication and before the Mantissa Insectorum was published as there is no page number given; the page number is 95.

BICOLOR, Erotylus

Fabricius 1775, p. 124, n. 8; 1801, 2, p. 14, n. 7 *(Cebrio)*
tardus Blk. 1889 p. 1271 *(Amarygmus)*
var *torridus* Pasc. 1869 p. 351
Junk's Catal. 1911, 18, 28, p. 578 *(Amarygmus)*
Zimsen 1964, p. 116, n. 1807
Carter 1926, p. 158

Holotype labels:
i. Fabricius "Erotylus Bicolor Fab. Entom. p. 124 n. 8"
ii. BMNH "Cnodulon bicolor", "Type"

Locality: "nova Hollandia"

Current status: *Amarygmus bicolor* (F.): Tenebrionidae, Amarygminae

Comment: The holotype is in a poor state of preservation. The ventral surface is covered with dirt and mycelium, except for the terminal joints of the right antenna all structures appear to be present but are difficult to discern. Carter (1915: p. 33) discusses the synonym of this species fully. This reference includes a copy of the correspondence between Carter and Blair of the BMNH who compared the Fabrician type with the type of *A. tardus* Blkb. which is in the BMNH. Fabricius changed the genus of this species in his later publication. This species is recorded in Junk's Catalogue (idem.) as a queried synonym of *Chalcopterus affinis* Bless. This is not accepted by Carter (idem.).

BICORNIS, Curculio

Fabricius 1781, 1, p. 180, n. 111; 1801, 2, p. 489, n. 241 *(Rhynchaenus)*
amplipennis Pasc. 1875, p. 218
purus Broun 1893, p. 1224 *(Tysius)*
Zimsen 1964, p. 208, 108, n. 3584
Kuschel 1970, p. 202

Lectotype (Kuschel 1970) labels:
i. Fabricius "Curc. Bicornis Fabr. Sp. Ins. n. 111"
ii. BMNH "Rhynchaenus bicornis", "Type"

Locality: "nova Zelandia"

Current status: *Tysius bicornis* (F.): Curculionidae, Erirrhininae

Comment: The lectotype is badly damaged; head, tarsi of right prothoracic leg, left prothoracic leg except for coxa and trochanter, and right metathoracic leg are missing. This species was for sometime omitted from the catalogues. G. Kuschel places this species in the genus *Tysius*. He regards this "type", a male, as the lectotype although the Fabrician reference says "Mus. Dom. Banks" and there is only one specimen in the collection. There is a female in Fabricius's own collection which he names as a paralectotype.

BIDENS, Lamia

Fabricius 1775, p. 177, n. 30; 1801, 2, p. 304, n. 124.
Junk's Catal: 1923, 23, 74, p. 604.
Zimsen 1964, p. 172, n. 2890.

Labels of specimen in collection:
i. Fabricius "Lamia Bidens Fab. Entom. p. 177 n. 30".
ii. BMNH "Lamia bidens". This label and the "Type label" have been crossed out and the word "Bidens" queried.
iii. A mutilated label—"an bidens fabricii?"

Locality: "nova Hollandia".

Comment: This specimen cannot be the "Fabrician type of *L. bidens*. It is in good condition but has been badly pinned. I have been unable to identify it. Aurivillus (Junk's Catal. idem.) and McKeown (1947: p. 174) both list this species among those "doubtful or unknown" genera. Oliver (1789: p. 67 Fab. 17 fig. 125) figures *L. bidens* F. as a small narrow insect with the apices of the reddish-brown elytra distinctly bidentate.

BIDENS, Curculio

Fabricius 1775, p. 136, n. 51; 1801, 2, p. 457, n. 96 *(Rhynchaenus)*
rufipes Broun 1881, p. 718 *(Nyxetes)*
Junk's Catal. 1934, 28, 140, p. 84 *(Nyxetes).*
Zimsen 1964, p. 203, n. 3474.
Kuschel 1970, p. 201.

Lectotype labels:
i. Fabricius "Curc. Bidens Fab. Entom. p. 136 n. 51".
ii. BMNH "Rhynchaenus", "Type".

Locality: "nova Zelandia".

Current status: *Nyxetes bidens* (F.): Curculionidae, Erirrhininae.

Comment: Glue is present on both dorsal and ventral surfaces; spine-like clusters of hairs on right elytron are broken, abdomen twisted and lying at right angles to the rest of body; antennae, most tarsi and right metathoracic leg are missing. The colour of this species varies from reddish brown to black, "type" is black. Fabricius changed the genus in his later publications. Kuschel designated this specimen as a lectotype.

BIFASCIATA, Crioceris (Lema)

Fabricius 1775, p. 120, n. 12; 1801, 1, p. 476, n. 29 *(Lema).*
Junk's Catal. 1924, 24, 51, p. 55 *(Lema).*
Zimsen 1964, p. 107, n. 1645.

Syntype labels:
i. Fabricius "Crioc. bifasciata Fab. Entom. p. 120, n. 12".
ii. BMNH "Lema bifasciata", "Type".

Locality: "nova Hollandia".

Current status: *Lema bifasciata* F.: Chrysomelidae, Criocerinae.

Comment: The condition of the "type" is fair, parts of the antennae and tarsi of right metathoracic legs are missing. The second specimen is not in as good a condition as the "type", and it is pinned through the left elytron. Fabricius re-classified this species in 1801 into the genus *Lema.*

BIPUSTULATUS, Scarabaeus

Fabricius 1775, p. 30, n. 121; 1801, 1, p. 62, n. 37 *(Ateuchus)*
Junk's catal. 1927, 19, 90, p. 209 *(Onthophagus)*
Zimsen 1964, p. 31, n. 188
Matthews 1972, p. 220 *(Onthophagus)*

Holotype labels:
i. Fabricius "Scarab. 2-pustulatus" Fab. Sp. Ins. No. 152
ii. BMNH "Ateuchus bipustulatus"

Locality: "nova Hollandia"

Current status: synonym of *Onthophagus quadripustulatus* (F.).

Comment: Holotype is badly pinned through the left elytron. Several legs are without tarsi and the club of the left antenna is missing. *O. bipustulatus* (F.) is a female and the synonym has been established by Matthews (idem).

BITUBERCULATUS, Curculio

Fabricius 1781, 1 p. 171, n. 58; 1801, 2, p. 438, n. 42
Junk's Catal. 1936, 30, 149, p. 111
Zimsen 1964, p. 199, n. 301
Kuschel 1970, p. 197

Holotype labels:
i. Fabricius "Curc. 2-tuberculatus Fabr. Sp. Ins. n. 58"
ii. BMNH "Calandra 2-tuberculata", "type"

Locality: "nova Zelandia"

Current status: *C. bituberculatus* F. is a synonym of *Sitophilus oryzae* Linné: Curculionidae, Rhynchophorinae.

Comment: The holotype is badly pinned, head and most tarsi are missing. Oliver (1807: p. 95 f. 167) describes this species, stating that the body is a ferrugineus uniform colour and without marks, and that the specimen in the Bank's Collection is without any raised tubercles on the prothorax as described by Fabricius. Herbst (1795: p. 29) and Broun (1880: p. 504) both note the same absence of tubercles. Kuschel (1970: p. 197) makes no reference to this. Kuschel determined the synonymy. He also explains the confusion caused in identifying this species as it had been erroneously associated with the weevils *Dryophthorus crenatus* Boisd. and *Mitrastethus baridioides* Redtenbacher.

BRUNNEA, Chrysomela

Fabricius 1781, 1 p. 123, n. 44; 1801, 1, p. 439, n. 104
Junk's Catal. 1914, 24, 59, p. 22
Zimsen 1964, p. 100, n. 1504

Holotype labels:
i. Fabricius "Chr. Brunnea Fabr. Sp. Ins. n. 44"
ii. BMNH "Chrysomela brunnea", "Type"

Locality: "nova Zelandia"—Zimsen (1964) and Musgrave (1952) record the locality as "nova Hollandia" as given by Fabricius in his 1781 publication. In his later publications of 1792 & 1801 Fabricius corrects this and gives the correct locality as "nova Zelandia".

Current status: *Eucolapsis brunnea* (F.): Chrysomelidae, Eumolpinae.

Comment: The condition of the holotype is poor, and the structures on the ventral surface are covered with glue and dirt. Parts of both antennae and parts of all legs are missing. There are several colour varieties of this species. The holotype is reddish and there is no trace of any green colour, as on some specimens, this may be due to fading. This species is described by Broun (1880: p. 622) and his account corresponds very closely to it, and the three specimens in his own collection are identical with the "type". Broun records the habitat as "New Zealand on the flowers of Leptospermum". Musgrave (1932: p. 87) incorrectly records the Fabrician genus as being *Coccinella.*

CANCROIDES, Lucanus

Fabricius 1787, 1, p. 2, n. 9; 1801, 2, p. 252, n. 18
Junk's Catal. 1960, 8, p. 39
Zimsen 1964, p. 162, n. 2071

Holotype labels:

i. Fabricius "Lucan. Crancroides Fabr. Mant. Ins. n. 9"
ii. BMNH "Lucanus Crancroides", "Type"

Locality: "Terra Diemenii"

Current status: *Lissotes crancroides* (F.): Lucanidae.

Comment: Holotype has been pinned twice, now through the right elytron but previously through the prothorax; mouth parts and tarsi covered in dirt; tarsi of right prothoracic and left metathoracic leg, and right mesothoracic leg are missing.

Westwood (1871: p. 371) gives a full description of this species, and compares it with closely allied species.

CARNIVORUS, Dermestes

Fabricius 1775, p. 55, n. 2, *(D. carniforus);* 1801, 1, p. 31, 2 n. 2
Junk's Catal. 1911, 14, 33, p. 42
Zimsen 1964, p. 64, n. 1048
Hinton 1945, p. 287

Locality: "in nova Hollandia et Zelandia" in 1775. "in nova Hollandia et in Germania" in 1801.

Current status: *Dermestes carnivorus* F.: Dermestidae

Comment: Fabricius changed the "habitat" in 1801 and added that the "type" was in "Dom Smidt", having previously in 1775 stated it was in "Mus. Dom. Banks". The spelling in 1775 of the species as "*carniforus*" is possibly a misprint as in all later publications it is spelt *carnivorus.* Hinton records the distribution of this species as "N. & S. America, Europe and India". According to Fauvel (1889) it is indigenous to America. It seems probable that this insect may have been found on the Endeavour, having been brought aboard with stores, thus giving rise to the confusion of its place of origin. This then is not an Australian or New Zealand species.

CLAVUS, Curculio

Fabricius 1775, p. 154, n. 140; 1801, 2, p. 536, n. 177
elegans Lea 1916 p. 332
Junk's Catal. 1931, 28, 114, p. 18 *(Leptops)*
Zimsen 1964, p. 219, n. 3789

Holotype labels:

i. Fabricius "Curcul. Clavus Fab. Entom. p. 154 n. 140'
ii. BMNH "Curculio clavus", "Type".

Locality: "nova Hollandia"

Current status: *Leptopius (Oke 1951) clavus* (F.): Curculionidae, Leptopiinae.

Comment: Holotype is pinned through the left elytron, tarsi of left prothoracic leg and right mesothoracic leg are missing. This species varies in colour and intensity of red markings and in the number of scales present.

COLLARIS, Tritoma

Fabricius 1775, p. 69, n. 2
bicolor Carter *(Sclerocyphon)* new synonym.
Zimsen 1964, p. 237, n. 4109

Holotype labels: Fabricius "Tritoma Collaris Fab Entom. 69 n. 2"

Locality: "nova Hollandia"

Current status: *Sclerocyphon collaris* (F.): Psephenidae.

Comments: There is no BMNH label. This speciment was added at the end of the named specimens in the collection after it was found in 1964 by E. Zinsen "in the last box" of the collection, which consists of unnamed specimens.

The condition of the type is very poor. The antennae and the abdomen are missing. The right side of the prothorax is broken, but the broken piece is lying on top of the prothorax. It is badly pinned and the right elytron is cracked. There is a large lump of glue on the ventral surface and the insect is covered with dried mycelial hyphae and debris.

This species has not only been omitted from the catalogues but Fabricius omitted it from his 1801 publication, the Systema Eleutheratorum. It is listed in his Species Insectorum and in Mantissa Insectorum. However, the omission from the Eleutheratorum may account for the fact that it was not found in the arrangement of the Banks Collection which was based on the order given in that publication. While I was studying the collection R. D. Pope of the BMNH classified this specimen as a member of the family Psephenidae and as belonging to the genus *Sclerocyphon.* (pers. com.) While at the BMNH I compared it with H. J. Carter's (1935: p. 191) description of *S. bicolor.* This described the Fabrician species, *T. collaris* F. There was no speciment of *S. bicolor* Carter in the BMNH, so no comparison could be made. On returning to Australia, I was eventually able to track down a paratype of *S. bicolor* Carter at the Zoology Department at the University of Tasmania, where Mrs. J. Smith is making a study of the genus *Sclerocyphon.* The specimen was sent to R. D. Pope at the BMNH and he made a comparison of the two

species, and agrees that *S. bicolor* Carter is a synonym *T. collaris* F. In a letter received from Mr. Pope he states: "I have compared the Carter paratype with the specimen in the Banks Collection and am quite satisfied that they are the same species. The overall size, pronotal colour pattern and shape, elytra punctation and colour all agree well. The teeth on the hind margin of the pronotum from margin of the scutellum and basal borders of the elytra all correspond in size and distribution. The colour pattern and general morphology of the head also agree".

CRASSICORNIS, Chrysomela

Fabricius 1775, p. 99, n. 27; 1801, 1, p. 437, n. 94.
Junk's Catal. 1916, 24, 68, p. 193 *(Calomela).*
Zimsen 1964, p. 99, n. 1496.

Holotype labels:

i. Fabricius "Chrys. crassicornis Fab. Entom. p. 99, 27.
ii. BMNH "Chrysomela crassicornis" "Type".

Locality: "nova Hollandia".

Current status: *Calomela crassicornis* (F.): Chrysomelidae, Chrysomelinae.

Comment: The holotype is not in good condition. Glue on the ventral surface has covered the metathorax and abdomen; left mesothoracic and right metathoracic legs are missing. Baly (1855: p. 249) gives a detailed description of this species. However, the black markings on the "type" differ somewhat from what Baly describes as typical of the species. The general colour is fulvous, the "type" being paler than most specimens in the BMNH, but this may be due to fading. The "type" differs from Baly's description in the following respects:—

1. no dark frontal patch on head
2. no black marking on prothorax
3. markings on each elytron are a single rounded black basal spot, and an elongated black streak posterior to it. Baly describes the elytral markings as a "subtriangular spot near the scutellum and a sinous vitta . . . extends nearly to the apex of the elytron".

CRENULATUS, Curculio

Fabricius 1775, p. 147, n. 105; 1801, 2, p. 518, n. 64, *australis* Boisd. *(Gastrodus).*
Junk's Catal. 1913, 28, 114, p. 16.
Zimsen 1964, p. 214, n. 3696.

Holotype labels:

i. Fabricius "Curc. Crenulatus Fab. Entom. p. 147, n. 105".
ii. BMNH "Curculio crenulatus", "Type".

Locality: "nova Hollandia".

Current status: *Stenocorynus crenulatus* (F.): Curculionidae, Leptopiinae.

Comment: Holotype is pinned through left elytron; terminal joints of both antennae and tarsi of left metathoracic leg are missing, it is also very abraded only a few scales are present.

CRISTA, Lamia

Fabricius 1775, p. 170, n. 3; 1801, 2, p. 282, n. 6.
Junk's Catal. 1922-23, 23, 74, p. 323.
Zimsen 1964, p. 167, n. 2787.

Holotype labels:

i. Fabricius "Lamia Crista Fab. Entom. p. 170 n. 3".
ii. BMNH "Lamia crista", "Type".

Locality: "nova Zelandia".

Current status: *Hybolastus cristus* (F.): Ceramycidae, Lamiinae.

Comment: The holotype is in fairly good condition; pinned through the left elytron which is cracked; terminal joints of both antennae and tarsi of right metathoracic leg are missing. Broun (1880: p. 609-10) states that he examined the Fabrician type and noted that Fabricius made an error when he described the basal tubercles of the elytra as tridentate. The mistake is due to the fact that the tubercle is surmounted by "a compressed pencil of hairs".

CRUCIATA, Buprestis

Fabricius 1775, p. 222, n. 36; 1801, 2, p. 210, n. 134.
Junk's Catal. 1935, 12, 143, p. 844.
Zimsen 1964, p. 155, n. 2568.
Carter 1923, p. 172 and 1929 p. 277.

Holotype labels:

i. Fabricius "Buprestis cruciata Fab. Entom. p. 222 n. 36".
ii. BMNH "Buprestis cruciata", "Type".

Locality: "nova Hollandia".

Current status: *Cisseis s.g. Neospades cruciata* (F.): Buprestidae, Buprestinae.

Comment: The holotype is in good condition except for a large amount of glue on the ventral surface. Carter (1929: p. 277) classified this species in the genus *Neospades* which is now a sub-genus of *Cisseis.*

CRUCIATUS, Curculio

Fabricius 1775, p. 129, n. 8; 1801, 2, p. 434, n. 23 *(Calandra)*
doriae Pasc. 1885 p. 257, new synonym
Junk's Catal. 1936, 29, 151, p. 151
Zimsen 1964, p. 198, n. 3386

Holotype labels:
i. Fabricius "Curc. cruciatus Fabr. Entom. p. 129 n. 8"
ii. BMNH "Calandra cruciatus"
iii. "Crypto-rhynchus"

Locality: "nova Hollandia"

Current status: unknown: Curculionidae, Cryptorrhynchinae.

Comment: All structures appear to be complete though the legs are all tightly contracted and folded inwards, there is a great deal of glue on the ventral surface. There is no museum "type" label on this speciment although the label has the original reference on it. In correspondence with R. J. Thompson of the BMNH he sent the following communication to me "I have compared the types of *cruciatus* and *Acalles doriae* Pasc. and confirm that they belong to the same species. Although *doriae* stands in *Ophrythyreoces* in Junk's Catalogue (Hustache 1936), it certainly does not belong there. In his description of *Ophrythyreocis,* Lea draws special attention to the "conspicuously elevated scutellum" (1913: p. 245) but in *doriae* the scutellum is absent. Lea (idem, p. 247 note) placed *doriae* in *Pseudoporopterus, along with P. irrasus* (idem, p. 246). Although *doriae* and *irrasus* are probably congeneric, I doubt if they really belong in *Pseudoporopterus".*

CULTRATUS, Curculio

Fabricius 1775, p. 153, n. 136; 1801, 2, p. 536, n. 173
bicristatus F. 1801, 2 p. 517
Junk's Catal. 1936, 28, 150, p. 3 *(Aterpus)*
Zimsen 1964, p. 219, n. 3785

Holotype labels:
i. Fabricius "Curc. cultratus Fab. Entom. p. 153 n. 136"
ii. BMNH "Curculio cultratus", "Type"

Locality: "nova Hollandia"

Current status: *Aterpus cultratus* (F.): Curculionidae, Aterpinae.

Comment: All structures are complete, but the ventral surface is covered with dirt. This is a well known species. Fabricius (1775: p. 153) describes the elytra with "tuberculis sex v. septem elevatis" (six to seven elevated tubercles). The holotype has only five distinct tubercles.

CUPREUS, Erotylus

Fabricius 1775, p. 123, n. 5; 1801, 2 p. 12, n. 1 *(Cnodalon)*
venereus Gmel p. 1728 *(Chalcopterus)*
rusticus Blkb. Mon. p. 63, 76 *(Chalcopterus)*
setosus Blkb. by Blair (1914: p. 489) *(Chalcopterus)*
var *cupriventris* Carter *(Chalcopterus)*
Junk's Catal. 1911, 18, 28, p. 580 *(Chalcopterus)*
Zimsen 1964, p. 115, n. 1801
Carter 1926, p. 160

Holotype labels:
i. Fabricius "Cnodalon cupreum Fab. Ent. p. 123 n. 5"
The original name of *Erotylus cupreus* on the label has been changed to *Cnodalon cupreum* in the same handwriting. After re-examination of more species Fabricius must have done this himself. As his work progressed he often re-classified species in new genera.
ii. BMNH "Cnodalon cupreus", "type"

Locality: "nova Hollandia"

Current status: *Chalcopterus cupreus* (F.): Tenebrionidae, Amarygminae.

Comment: The condition of the holotype is good except for the head which is retracted within the prothorax. Only the terminal joints of the left antenna and terminal tarsi of left metathoracic leg are missing.

The synonyms of this species are given by Carter (idem.) as *Ch. venereus* Gmel and *Ch. rusticus* Blk. H. J. Carter (1913: p. 14) had some correspondence with K. G. Blair of the BMNH about this Fabrician species. In this reference Blair's description of the Fabrician type is given. Blackburn's type of *Ch. rusticus* and *Ch. setosus* are both in the BMNH. Blair (1914: p. 489) published that *Ch. setosus* Blk. is also a synonym. Carter (1926: p. 160), who had not seen the types still published them as separate species, omitting Blair's work on this species. The full synonymy should be as above.

This species shows great variation in colour from deep purple, almost black with a metallic tinge through various shades of purple with a green metallic tinge, to reddish copper, to an emerald green. The holotype is black with thorax and elytra coppery.

CURVIROSTRIS, Curculio

Fabricius 1781, 1, p. 166, n. 29; 1801, 2, p. 446, n. 40 *(Rhynchaenus).*
Zimsen 1964, p. 201, n. 3436.

Holotype labels:
i. Fabricius: "Curc. Curvirostris F. Sp. Ins. N. 23". This number 23 is incorrect; it should be 29.
ii. BMNH "Rhynchaenus curvirostris", "Type".

Locality: "nova Hollandia".

Current status: unknown. Family Curculionidae.

Comment: The holotype is in poor condition; head twisted through an angle of 90° to the left. Both antennae and some of the legs are missing, and the rest twisted and covered with dirt.

R. curvirostris F. does not appear in any recent catalogue. Olivier (1807: p. 152) described and figures this species. As Fabricius studied more and more species he realised that the large genus of *Curculio* had to be divided up into separate genera. This species was put in the genus *Rhynchaenus* in his later publications.

CYANEUS, Hister

Fabricius 1775, p. 52, n. 3; 1801, 1, p. 86, n. 13
speciosus Boisd. 1835, p. 148
laetus Er. 1834, p. 179.
Junk's Catal. 1910, 8, 24, p. 93 *(Saprinus).*
Zimsen 1964, p. 35, n. 253.

Labels: There are 3 specimens over the BMNH label "Hister cyaneus".
1. i. Fabricius "Hister cyaneus Nova Hollandia".
   ii. BMNH "Type".
2. No labels.
3. Fabricius "Hister cyaneus C.B.S. Fab. Ent. p. 52 n. 3".

Locality of "Type": "nova Hollandia".

Locality of 3rd specimen: "C.B.S." (Cape of Good Hope).

Current status: *Saprinus cyaneus* (F.): Histeridae.

Comment: Both labelled specimens are pinned through the left elytron with a large amount of glue on the ventral surface. The "type" is complete except for the tarsi of the right meta-thoracic leg. The specimen labelled as from "C.B.S." is in poor condition with right antenna and most legs missing. The unnamed specimen is the same species as the "type", so both specimens may be taken as syntypes. The second specimen is in much the same condition as the "type". These specimens were compared with the large series in the BMNH collection of *S. cyaneus* (F.). It is a species that varies a good deal in size and colour from green to blue, also in degree and form of striation on the elytra. In none of the species examined was the sutural and second striae united anteriorly, as they are in the specimen with the "habitat" given as "C.B.S." (Cape of Good Hope). This specimen was compared with the specimens of *S. bicolor* (F.), the type of which is in the BMNH collection and the "C.B.S." specimen proved to be that species. The type of *S. bicolor* (F.) of South Africa is given in Syst. El. 1801, 1 p. 86, n. 14 as being in Mus. D. de Schestedt, and the locality is given as "C.B.S." It appears then that this specimen has been erroneously labelled *Hister cyaneus* with the reference "Fab. Ent. p. 52 n. 3" which is for *H. cyaneus*. The locality C.B.S. on the label is correct for *H. bicolor*. There has obviously been some mixing of material here. This specimen of *H. bicolor* may be a syntype as the label is in Fabricius's handwriting.

CYANEUS, Lagria

Fabricius 1775, p. 125, n. 4; 1801, 2 p. 68, n. 5 *(Dryops)*
chalybeus White ♂ *(Selenopalpus)*
subviridus White ♀ *(Selenopalpus)* new synonym
Junk's Catal. 1915, 17, 65, p. 24 *(Selenopalpus)*
Zimsen 1964, p. 127, n. 2026

Holotype labels:
i. Fabricius "Lagria Cyanea Fab. Entom. p. 125 n. 4"
ii. BMNH "Dryops cyanea", "Type"

Locality: "nova Hollandia" is the locality given by Fabricius and recorded as such by Zimsen. It is, however, a New Zealand species (Broun 1880: p. 420).

Current status: *Selenopalpus cyaneus* (F.): Oedemeridae

Comment: Pin has forced the elytra apart; glue on the ventral surface has entangled meso and metathoracic legs; abdomen has been broken off and glued on at a slight angle; joints of both antennae and left maxillary palp are missing.

White's types of *S. chalybeus* and *S. subviridus* are in the BMNH collection. *S. chalybeus* is a male and this synonymy was published by Broun (1880: p. 420). On examination *S. subviridus* white is found to be the female of *S. chalybeus* White and is, therefore, another synonym of *S. cyaneus* (F.) Schenkling in Junk's Catalogue published all three as separate species, ignoring Broun's publication. *Sclenopselophus* is another generic synonym.

CYANEUS, Scarites

Fabricius 1775, p. 249, n. 2; 1801, 1, p. 125, n. 13.
fabricii Westw 1842, 1, p. 85
var *aenescens* Sloane 1923, p. 19.
Junk's Catal. 1927, 1, 91, p. 451 *(Laccopterum)*
Zimsen 1964, p. 41, n. 376

Holotype labels:
i. Fabricius "cyaneus"
ii. BMNH Scarites cyaneus

Locality: "nova Hollandia"

Current status: *Laccopterum cyaneum* (F.): Carabidae, Scaritinae

Comments: The specimen is badly pinned through the mid-dorsal line forcing the elytra apart. The ventral surface is covered with glue. The left

mesothoracic leg is missing, the metathoracic leg is detached and lying in the glue.

CYANICORNIS, Chrysomela

Fabricius 1775, p. 99, n. 24; 1801, 1 p. 436, n. 85.
Junk's Catal. 1916, 24, 68, p. 200 *(Phyllocharis)*
Zimsen 1964, p. 99, n. 1489

Holotype labels:
i. Fabricius "Chrys. Cyanicornis Fab. Entom. p. 99".
ii. "Chrysomela cyanicornis", "Type"

Locality: "nova Hollandia"

Current status: *Phyllocharis cyanicornis* (F.) Chrysomelidae, Chrysomelinae

Comment: The holotype is pinned through the left elytron, the posterior half of which is missing, only the coxa and trochanter of left mesothorac leg is present. There are several varieties of this species. As in the other species of this genus there is tremendous variation in colour patterns. This holotype has a single central prothoracic spot and eight spots distributed over the elytra, one basal spot and two marginal ones on each elytron, and one central and one triangular apical spot each with half on each elytron. Lea (1902 p. 402) suggests that this species is a variety of *P. cyanipes* (F.). It needs a specialist in this group to decide which are valid species and which are varieties.

CYANIPES, Chrysomela

Fabricius 1775, p. 98, n. 23; 1801, 1 p. 436 n. 84.
Junk's Catal. 1916, 24, 68, p. 201 *(Phyllocharis)*
Zimsen 1964, p. 99 n. 1488

Holotype label:
i. Fabricius "Chrys. Cyanipes Fab. Entom. p. 98 n. 23".
ii. BMNH "Chrysomela cyanipes" "Type"

Locality: "nova Hollandia"

Current status: *Phyllocharis cyanipes:* Chrysomelidae, Chrysomelinae

Comment: The condition of the holotype is fair. Left antenna and some tarsi are missing, and there is a large crack between the metathorax and abdomen, also there is a great deal of glue on the ventral surface

There are a number of colour pattern varieties of this species listed in Junk's Catal (idem). Also Baly (1855: p. 172) describes and discusses these varieties fully. He states that the Fabrician type was founded on a single specimen which he, Baly, regards as an extreme variety. There are two blue spots on each elytron in the holotype specimen, one basal spot near the sutural angle and one slightly posterior to it nearer the external margin. The posterior half of the elytra is dark blue with a ramus running up each side of the suture. There is a small ferrugineous apical spot. This species is recorded from New Guinea and Northern Australia.

CYANOCEPHALA, Crioceris

Fabricius 1775, p. 121, n. 18; 1801, 1, p. 461, n. 58
antennalis Lea 1923: p. 521 and p. 543, new synonym.
Zimsen 1964, p. 104, n. 1591.

Syntype label:
i. Fabricius "Cr. Cyanocephala Fab. Entom. p. 121 p. 18".
ii. BMNH "Crioceris cyanocephala"

Locality: "nova Hollandia"

Current status: *Monolepta cyanocephala* (F.) Chrysomelidae, Galerucinae.

Comment: There are two specimens on the Fabrician label, neither of which has been identified by Waterhouse as the type, therefore both must be regarded as syntypes. Zimsen records only one. Both are in a very bad state of preservation. One specimen, being badly pinned is very distorted and the structures so twisted and superimposed on one another, it is difficult to distinguish the characters; both antennae are damaged. In the other specimen the membraneous wings are unfolded and protrude beyond the elytra, the antennae are damaged and parts of the right one are carded. The ventral surface is in a better condition than the previous specimen and only the tarsi of the metathoracic legs are missing. This is a male; the sex of the other specimen is indiscernable.

This species has been omitted from recent catalogues. Hope (1840: p. 145) mentions it in his list of Fabrician species under the original genus of *Crioceris*. J. W. Wilcox does not mention it in Junk's Supplement 1971-74. In 1929, G. E. Bryant of the Entomological Bureau, London, identified this species as belongong to the genus *Monolepta*. T. Blackburn (1896: p. 99) states "I have not seen any Galerucid agreeing with the description of this species, but it does not seem at all likely to be a true *Monolepta* as its author states that the third joint of its antenna is as long as the fourth". On examination of this specimens this is not the case. The second and third joints are very small, the fourth and fifth joints are longer and equal in size, and joints six to eleven are longer than the second and third joints, but shorter than four and five.

In the BMNH there are four cotypes, two males and two females, of *M. antennalis* Lea. On comparing these with *M. cyanocephala* (F.) they are found to be identical. *M. antennalis* Lea then

becomes a synonym of *M. cyanocephala* (F.). Mrs. S. L. Shute of the BMNH verified this synonymy.

CYLINDRIROSTRIS, Curculio

Fabricius 1775, p. 137, n. 55; 1801, 2, p. 463, n. 125 *(Rhynchaenus)*
innubus Herbst 1792-5, p. 172.
longimanus Boisd. 1835, p. 408 *(Orthorrhinus)*
var. *simulans* Boh. 1836, p. 245
var. *laetus* Saund. and Jekel 1855, p. 297
var. *aspreda* Pasc. 1882, p. 380
var. *carbonarius* Pasc. 1882, p. 381
var. *lateralis* Pasc. 1882, p. 381
var. *euchromus* Fairm. 1883, p. 36
var. *patreulis* Pasc. 1885, p. 225
var. *vagus* Olliff. 1889, p. 89
var. *pomicola* Lea 1897, p. 624
var. *albiceps* Lea 1897, p. 624
var. *howensis* Lea unpublished.
Junk's Catalogue 1932, 28, 122, p. 46 *(Orthorrhinus)*
Zimsen 1964, p. 204, n. 3491

Holotype labels:
i. Fabricius "Curc. cylindrirostris Fabr. Entom. p. 137 n. 55".
ii. BMNH "Rhynchaenus cylindriostris", "Type".

Locality: "nova Hollandia"

Current status: *Orthorrhinus cylindrirostris* (F.): Curculionidae, Hylobiinae.

Comment: Holotype is black with scattered greyish and brownish scales. This is a common species which varies considerably in size and number of scales present. In Junk's Catalogue *O. laetus* Saund. and Jekel and *O. lateralis* Pasc. are listed as separate species. Before A.M. Lea died in 1932 he sent me a copy of his MS notes on Lord Howe Island Coleoptera. These have not been published. In these notes he states that both *O. lateralis* Pasc and *O. laetus* Saund. are varieties of *O. cylindrirostris* (F.). I quote from Lea's MS:—

"*O. cylindrirostris Fab. var. lateralis Pasc.*
Six specimens were obtained; four with white markings conspicuous, two with them rather vaguely indicated.
O. cylindrirostris, var. *vagus* Oll. This var. was very abundant on freshly felled trees at night time, and was a common victim of *Cormodes darwini*.
O. cylindrirostris, var howensis Lea. a new variety.

A large var. 14-18 mm. Scales nearly all of a creamy whiteness except in the vicinity of the fascicles; elytral fascicles more or less ochreous, only the median pair very conspicuous, apical fascicles of prothorax feeble or absent. Rostrum long and thin; front legs long in both sexes, but in male considerably longer than in female and the front tarsi wide, flat, and with conspicuous fringes.

Specimens of this var. in good condition have a curious speckled appearance owing to the abundant granules showing through the scales; but greasy or dirty specimens look very different. Twelve males and seven females were obtained in company with specimens of the preceding var. i.e. var. *vagus* Oll."

These MS notes were sent to me in December 1931. In a covering letter to me A.M. Lea stated that var. *howensis* Lea was close to var. *laetus* Saund and Jekel from the New Hebrides.

In the BMNH Collection under the label *O. laetus* Saund and Jekel which is in Jekel's handwriting is a specimen with the label *O. cylindrirostris* (F.) identified by A.M. Lea as var. *howensis* Lea. There are 2 locality labels on this specimen, (1) Lord Howe Is. A.M. Lea and a BMNH label, Australia. Variety *howensis* Lea is therefore a variety of *O. cylindrirostris* and according to Lea *O. laetus* Saund and Jekel and *O. lateralis* Pasc. should be regarded as varieties also.

DECEMPUNCTATUS, Dytiscus

Fabricius 1775, p. 232, n. 11; 1801, 1, p. 263, n. 26
ab. *flavoscriptus* Zimmerm. 1917, p. 213 *(Platynectes)*
ab. *lugubris* Blanch. 1853, p. 49 *(Platynectes)*
var. *masteri* Macl. 1871, p. 126 *(Platynectes)*
var. *octodecimmaculatus* Macl. 1825, p. 31 *(Platynectes)*
var. *semperi* Reg. 1899, p. 285 *(Platynectes)*
var. *spilopterus* Germ. 1848, p. 172 *(Platynectes)*
var. *variegatus* Reg. 1899, p. 286 *(Platynectes)*
Junk's Catal. 1920, 4, 71, p. 149 *(Platynectes)*
Zimsen 1964, p. 68, n. 879
Zimmermann 1917-19, p. 213

Syntype labels:
i. Fabricius "Dytisc. 10—punctatus Fab. Entom. p. 232 n. 11"
ii. BMNH "Dytiscus 10—punctatus", "Type"

Locality: "nova Hollandia". This species is very widespread and has also been recorded from the islands of Indonesia, Philippines and New Guinea.

Current status: *Platynectes decempunctatus* (F.): Dytiscidae

Comment: The condition of the "type" is good, only the left mesothoracic leg and tarsal joints of the right and left metathoracic legs are missing. This species has a great many varieties which are recorded by Zimmermann in Junk's Catalogue (1920). Both Sharp (1882: p. 540) and Zimmermann (1917, 1919: p. 213) give full accounts of this species. The varieties differ mainly in the markings of the yellow spots. The "type" has a large distinct anterior spot on the head, one spot on each anterior angle of the prothorax, five yellow spots on each elytron

arranged in two longitudinal rows—three in the inner row near the suture, and two outer lateral spots situated slightly posterior to the inner anterior and medial spot. The dorsal surface of the type is dull, this may be due to dirt and age. All the specimens in the BMNH collection are shiny.

DETRITA, Coccinella

Fabricius 1775, p. 85, n. 36; 1801, 1, p. 373, n. 98
?amica Newman 1842, p. 415 *(Paropsis)*
laesa Germ. 1848, p. 235 *(Paropsis)*, new synonym.
conferta Chap. 1877, p. 81 *(Paropsis)*
Zimsen 1964, p. 76, n. 1237

Holotype labels:
i. Fabricius "Coccin. Detrita Fab. Entom. p. 85 n. 36"
ii. BMNH "Coccinella detrita"

Locality: "nova Hollandia"

Current status: *Paropsis detrita* (F.): Chrysomelidae, Chrysomelinae

Comment: Condition of holotype is poor. The insect has been broken and roughly glued together. Parts of the antennae, the labial palps and parts of all legs except for those of the right meso and metathoracic legs are missing.

This species was classified as a coccinellid by Fabricius. Hope (1840: p. 87) refers it to the genus *Paropsis* but makes no further comment on it. It does not appear in either Gemminger et Harold's catalogue nor in Junk's catalogue. In 1929 G. E. Byrant of the Entomological Bureau of London checked this synonymy and agreed that it was the same as the species *P. (Chrysophtharta) laesa* Germ. (1948: p. 235). *P. detrita* (F.) is therefore the valid name and *P. laesa* Germ is a new synonym. Blackburn's (1899: p. 493) description of *P. laesa* Germ. describes the "type" specimen of *P. detrita* (F.). The above synonyms are given in Junk's Catalogue 1916, 24, 68, p. 164 for *P. laesa* Germ.

DETRITUS, Hister

Fabricius 1775, p. 53, n. 10; 1801, 1, p. 89, n. 28
Junk's Catal. 1910, 8, 24, p. 93 *(Saprinus)*
Zimsen 1964, p. 35, n. 262

Holotype labels:
i. Fabricius "Hister detritus Fab. Entom. p. 53 n. 10"
ii. BMNH "Hister detritus", "TYPE"

Locality: "nova Hollandia". This is probably a New Zealand species.

Current status: *Saprinus detritus* (F.): Histeridae.

Comment: The condition of the type is fair except for the legs, one of which is entirely missing and the others are in a bad state of preservation. There is also a good deal of dried fungal hyphae present.

H. Bickhardt in Junk's Catalogue (idem.) lists *S. detersus* Illiger, (1807: p. 365) and queries *S. detritus* Rossi (1790: p. 29) as a synonym. Fabricius (1927: p. 76) refers to Rossi's and Olivier's descriptions. Rossi was not the author of the species. Both Fabricius and Olivier (1789: p. 12) give "nova Hollandia" as the locality. The locality of *S. detersus* Ill. is a Mediterranean and Western European species. R. Staig (1931: p. 102) lists *S. detritus* (F.) as the species and *S. detersus* Ill. as a synonym. He notes that in the Fabrician reference 1787 p. 33 the specific name is spelt as *detricus*, which is probably a misprint. *S. detritus* (F.) has been omitted from recent catalogues. On comparison of the type of *S. detritus* (F.) with specimens of *S. detersus* Ill. in the BMNH collection, it is evident that these two species are not identical and should be regarded as two distinct species.

Characters of *S. detritus* (F.):—Head and thorax black, elytra deep red. Head:—punctation slight and scattered. Prothorax:—anterior margin fringed with hairs, transverse, slightly bisinuate at base, anterior angles rounded but projecting, lateral and posterior margins punctate with punctures fading out towards centre on posterior margin, disc smooth and shiny and under magnification very fine punctures are visible. Elytra:—oblong, almost rectangular, slighty swollen at humeral angle, lateral edges bent sharply at right angles, posterior half of elytra coarsely and densely punctate, on lateral margins punctures extend up to two-thirds of length of elytra and reach anterior margin between third and fourth striae. Five striae are distinguishable in anterior half, and first and second striae are united anteriorly. No striae are distinguishable in posterior half.

Legs:—External margin of tibiae of pro- and mesothoracic legs have four strong denticles and two small ones at apex. The metatibiae have spines on external margin.

Abdomen:—Ventral surface punctated, propygidium and pygidium also punctated.

In the BMNH there are several unidentified specimens from New Zealand. On comparing them with the type of *S. detritus* (F.) they appear to be the same species. It is probable therefore that the Fabrician locality "nova Hollandia" is incorrect and should be "nova Zelandia".

DEUSTA, Cassida

Fabricius 1775, p. 89, n. 8; 1801, 1, p. 396, n. 44
corallina Boisd 1835, p. 541
angulifera Blanch. 1853, p. 324
Junk's Catal. 1914, 25, 62, p. 70 *(Aspidomorpha)*
Zimsen 1964, p. 90, n. 1313

Syntype labels:

i. Fabricius "Cassida deusta Fab. Entom. p. 89 n. 8"

ii. BMNH "Cassida deusta" "Type"

Locality: "nova Hollandia"

Current status: *Aspidomorpha deusta* (F.): Chrysomelidae, Cassidinae.

Comment: The "type" is in fair condition. The terminal joints of the left antenna, the terminal tarsi of the mesothoracic legs and the left metathoracic leg are all missing. There is a second specimen which is cleaner than the "type" but both right meso- and metathoracic legs and the tarsi of the left metathoracic leg are missing.

The number of spots arranged in three longitudinal rows on the elytra varies considerably in this species. They may be absent or two or three may unite. If present, the position of the spots remain constant. The holotype has five spots in the sutural and median lines and four in the marginal line with three of them fusing.

A. nigrodorsata Boh., given in Junk's Catal. (idem.) as a subspecies, has two black median spots missing on the elytra but otherwise is in close agreement with *A. deusta* (F.).

DIDYMUS Cryptocephalus

Fabricius 1775, p. 107, n. 9; 1801, 2, p. 43, n. 11.
ab. fulvoplagiata Jac. 1884, p. 210
Junk's Catal. 1914, 24, 59, p. 92 *(Rhyparida)*
Zimsen 1964, p. 122, n. 1923

Syntype labels:

i. Fabricius "Crypt. didymus Fab. Entom. p. 107 n. 9"

ii. BMNH "Cryptocephalus didymus", "Type"

Locality: "nova Hollandia"

Current status: *Rhyparida didyma* (F.) Chrysomelidae, Eumolpinae.

Comment: The "type" is badly damaged. Both antennae and all legs are incomplete, posterior half of right elytron is missing. There is a second specimen but it also is in a poor condition with the glue on the ventral surface obscuring most of the structures, both elytra are complete.

The three spots on the eltyra may vary in size and shape in this species, may also be united or obsolete. In the "type" they are distinct, the basal spot which Fabricius describes as "postice didyma" (posteriorly divided into two) is semicircular in shape with one branch extended towards the sutural margin and a slight indication of a branch given off medianly towards the outer margin, the central spot is roughly triangular and the apical one is elongate.

ERYTHROCEPHALUS, Staphylinus

Fabricius 1775, p. 265, n. 6; 1801, 2, p. 593, n. 19.
punctatus Hope
Junk's Catal. 1914, 5, 57, p. 398
Steel 1949, p. 57-61
Zimsen 1964, p. 231, n. 3986

Holotype labels:

i. Fabricius "Staph. erythroceph. Fab. Entom. p. 265 n. 6"

ii. BMNH "Staphylinus erythrocephalus", "Type"

Locality: "nova Hollandia"

Current status: *Creophilus erythrocephalus* (F.) Staphylinidae, Staphyliniae

Comments: Holotype, a female, head is very much deflexed, membraneous wings are unfolded, terminal joints of left antenna missing and left prothoracic leg is broken at base of tibia. The second specimen, a female, had been identified by W. O. Steel (idem.) as *C. lania* Er. It is in fair condition, only right metathoracic leg is missing and membranous wings are unfolded.

C. erythrocephalus (F.) is widely distributed throughout Australia and is recorded from Tonga, Tahiti and Chile. In the BMNH there is the type of *C. punctatus* Hope which is marked as a synonym. W. O. Steel (idem.) records this and points out the differences between *C. erythrocephalus* (F.) and *C. lania* Er.

EXCLAMATIONIS, Curculio

Fabricius 1775, p. 133, n. 37; 1801, 2, p. 456, n. 89 *(Rhynchaenus)*
Zimsen 1964, p. 203, n. 3471

Holotype labels:

i. Fabricius "Curc. Exclamationis Fab. Entom. p. 133 n. 37"

ii. BMNH "Rhynchaenus exclamationis", "Type"

Locality: "nova Hollandia"

Current status: unkown. Fam. Curculionidae

Comment: The holotype is badly pinned through position of left elytron which is missing, pin emerges on ventral surface between metathorax and abdomen so that abdomen is nearly detached from the thorax, antennae hidden beneath rostrum; left prothoracic leg is missing.

There is no record of this species in recent catalogues. Olivier (1801 p. 155, f165) describes this species but the figure is poor and does not show any detailed structure. Fabricius changed the genus in his later publications to *Rhynchaenus*.

FARINOSA, Buprestis

Fabricius 1775, p. 219, n. 16; 1801, 2, p. 195, n. 50
var. *auroimpressa* Cast. and Gory. 1835, p. 20 *(Chrysodema)*
var. *impressa* Kerr. 1898, p. 118 *(Cyphogastra)*
var. *borneensis* kerr. idem, p. 251 *(Cyphogastra)*
Junk's Catal. 1926, 12, 84, p. 117 *(Cyphogastra)*
Zimsen 1964, p. 152, n. 2509

Holotype labels:
i. Fabricus "Buprestis farinosa Fab. Entom. p. 219 n. 16"
ii. BMNH "Buprestis farinosa", "Type"

Locality: "nova Hollandia". This Fabrician locality is probably incorrect. This species has only been recorded in the East Indies.

Current status: *Cyphogastra farinosa* (F.): Buprestidae, Chalcophorinae.

Comments: Holotype is pinned through the left elytron; terminal joints of both antennae and tarsi of left mesothoracic and both metathoracic legs are missing; ventral surface is covered with a fine golden powder adhering to the pubescence. There are several specimens of this species in BMNH collection and they are all from Java and Borneo. Banks may have collected this specimen when the *Endeavour* stopped at Batavia for repairs.

FASCIATA F., Cetonia

see STOLATA F. Cetonia

C. fasciata F. is a synonym of *C. stolata* F.

FELINUS Dermestes

Fabricius 1781, 1, p. 34, n. 11; 1801, 1, p. 314, n. 13
Junk's Catal. 1911, 14, 33, p. 43
Zimsen 1964, p. 77, n. 1057
Hinton 1945, p. 296

Syntype labels:
i. Fabricius "Felinus Fabr. Mant. Ins. n. 11" Kergulandel"
ii. BMNH "Dermestes felinus" Register number "63-46"

Locality: "Terra Diemenii" in 1781 reference. "Kergulandel" on the label. Kergulen Island or Land is an island in the South Indian Ocean. Cook charted its coast on his Third voyage before calling in at Adventure Bay, Tasmania. Nelson, the collector, was on board. It appears that Fabricius must have thought this island was off the coast of Tasmania.

Current status: *D. felinus* F. is a synonym of *D. ater* Degeer (1774: p . 223): Dermestidae. Lepesme (1939: p. 192) and Hinton (idem.) discuss this synonymy.

Comment: There are two specimens in the Banks Collection, one of which has the BMNH type label. This is in the better condition. Head is sharply deflexed and some of the tarsi are missing. Zimsen only records one specimen in the Banks Collection.

FESTIVA, Melolontha

Fabricius 1775, p. 36, n. 23; 1801, 2, p. 171, n. 63
festa Gmelin 1788, p. 1561 *(Calonota)*
munda Sharp 1876, p. 73 *(Pyronota)*
var *laeta* F. 1775, p. 36, n. 24
Junk's Catal. 1912, 20, 47, p. 90 *(Calonota)*
Zimsen 1964, p. 146, n. 2390

Syntype label:
i. Fabricius "Melo. Festiva Fabr. Sp. Ins. No. 31"
ii. BMNH "Melolontha festiva", "Type"

Locality: "nova Zelandia"

Current status: *Calonota festiva* (F.): Scarabaeidae, Melolonthinae

Comment: The "type" is in good condition. It is pinned through the left elytron; right prothoracic leg except for coxa, and tarsi of left metathoracic leg are missing. There is a second specimen which is not recorded by Zimsen, the condition of which is only fair, it has been broken at the base of the prothorax and then glued together. This species must have been re-examined by Fabricius who put the later reference 1781 on the label when compiling the list for this publication.

There are a number of colour varieties of this species of which *Melolontha laeta* F. is one.

GIGAS, Ptinus

See GRISEUS F. Anthribus

P. gigas F. is the junior homonym.

GRISEA, Saperda

Fabricius 1775, p. 186, n. 9; 1801, 2, p. 324, n. 37
heteromorpha Boisd. 1835 *(Lamia)*
lentus Newm. 1840, p. 12 *(Xylotoles)*
westwoodi Guer. 1847, p. 27 *(Xylotoles)*
Junk's Catal. 1922, 23, 73, p. 3 *(Xylotoles)*
Zimsen 1964, p. 175, n. 2966

Syntype labels:
i. Fabricius "Saperda Grisea Fab. Entom. p. 186 n. 9"
ii. BMNH "Saperda grisea", "Type"

Locality: "nova Zelandia"

Current status: *Xylotoles griseus* (F.): Cerambycidae, Lamiinae

Comment: This is a small insect. The "type" specimen is pinned through the right elytron which it has displaced. There is a great deal of glue present on both dorsal and ventral surfaces and entangling the legs; both antennae, except for the basal joint of the left one, and the left elytron are missing.

There is a second specimen which, is cleaner than the "type" and left antenna and left elytron are complete, but right elytron is broken and abdomen is displaced.

Broun (1880: p. 593) attributes this species erroneously to Westwood (1843: p. 27) and gives *S. grisea* F. as a synonym. Westwood's description has a much later date, i.e., 1843.

GRISEUS, Anthribus

Fabricius 1775, p. 63, n. 1 *(Ptinus gigas);* 1801, 2, p. 410, n. 22
gigas F. 1775 p. 63 *(Ptinus)*
longicornis F. 1798 Suppl., p. 160
subsp. *cervinus* Klug. 1833, p. 188
nigroungulatus Fahrs. 1839, p. 241
Junk's Catal. 1929, 26, 102, p. 86 *(Phloeobius)*
Zimsen 1964, p. 193, n. 3297

Locality: "nova Hollandia". Its known distribution is now from New Guinea to Australia.

Current status: *Phloeobius griseus* (F.) Anthribidae.

Comment: The holotype is missing from the collection. In the original description (1775) Fabricius adds "an proprii genesis", a genus of its own. In the 1792 and 1801 publications, Fabricius changed not only the generic but also the specific name to *Anthribus griseus*. This species is now in the genus *Phloeobius* (Schk. 1826: p. 36) and the valid specific name is *griseus* according to the International Code.

GUTTATOPUSTULATA, Coccinella

Fabricius 1775, p. 87, n. 51; 1801, 1, p. 385, n. 153
Junk's Catal. 1931-32, 16, 118, p. 32 *(Epilachna)*
Zimsen 1964, p. 88, n. 1273

Holotype labels:
i. Fabricius "Cocc. guttato-pustulata Fab. Entom. p. 87 n. 51"
ii. BMNH "Coccinella guttato-pustulata"

Locality: "nova Hollandia"

Current status: *Epilachna guttatopustulata* (F.): Coccinellidae

Comment: The holotype is very dirty and there is a great deal of glue on the ventral surface.

The species is a well known leaf-eater.

HAEMORRHOIDALIS, Curculio

Fabricius 1775, p. 140, n. 71; 1801, 2, p. 484, n. 215 (Rhynchaenus)
Zimsen 1964, p. 208, n. 3567

Syntype labels:
i. Fabricius "Curc. haemorrhoidalis Fab. Entom. p. 140 n. 71"
ii. BMNH "Rhynchaenus haemorrohoidalis", "Type"

Locality: "nova Hollandia"

Current status: *Haplonyx haemorrhoidalis* (F.) Curculionidae, Haplonychinae.

Comment: They are two specimens, male and female. The male has the "type" label, it is badly pinned through left elytron, the abdomen has been pushed out of place and lies at right angles to the body plane; the specimen is badly abraded.
Female specimen is in good condition but is also badly abraded.

This species has been omitted from recent catalogues. In the BMNH there are specimens of this species labelled *Melanterius haemorrhoidalis* (F.).

Both E. C. Zimmermann of C.S.I.R.O. Canberra and R. T. Thompson of BMNH (pers. comm.) place this species in the genus *Haplonyx*.

HIRTA, Saperda

Fabricius, 1775, p. 184, n. 4; 1801, 2, p. 320, n, 13 *(S. villosa)*
villosa F. 1801
Junk's Catal. 1912, 22, 39, p. 115 *(Oemona)*
Zimsen 1964, p. 174, n. 2945

Syntype labels:
i. Fabricius "Saperda hirta Fab. Entom p. 184 n. 4"
ii. BMNH "Saperda hirta", "type"

Label of 2nd specimen: BMNH "Saperda villosa F. Syst. El."

Locality: "nova Zelandia"

Current status: *Oemona hirta* (F.): Cerambycidae, Cerambycinae.

Comment: The "type" is a male, its condition is fair, terminal joints of both antennae, right prothoracic leg except for coxa, tarsi of left prothoracic leg and both metathoracic legs are missing. The second specimen is a female, its condition is poor and it is badly rubbed. It has the BMNH label "Saperda villosa F. Syst. El." This labelling indicates that this was labelled when the collection was arranged in the order given in the Systema Eleutheratorum, as in that reference Fabricius gives the specific name as *villosa* and *hirta*

as the synonym as nov. nom., as he considered the name was preoccupied. He had used the specific name of *hirta* for a second species of *Saperda*, described first in 1792, p. 317, the locality of which is given as Italy. The New Zealand species however, is the senior homonym and therefore is the valid name for this specimen and *villosa* is the synonym. There is a large series in the BMNH of this species, and it shows great variation in size. Broun (1880: p. 570 and p. 1275) gives a detailed description of it. However, the type differs from this description as it has a smooth vertex, a dense patch of bright yellow hairs in the emarginate portion of the eye and another posterior to the eye. There is no indication of a smooth dorsal line on the prothorax. Also there is no pubescence along the dorsal line, but this may be due to rubbing. The elytra are also devoid of hairs.

HOLLANDIAE F., Scarabaeus

See *NOVAEHOLLANDIAE, F., Scarabaeus*

INAEQUALIS, Coccinella

Fabricius 1775, p. 80, n. 8; 1801, 1, p. 362, n. 40
Junk's Catal. 1931-32, 16, 120, p. 292 *(Coelophora)*
Zimsen 1964, p. 84, n. 1197

Holotype labels:
i. Fabricius "Cocc. inaequalis Fab. Entom. p. 80 n. 8"
ii. BMNH "Coccinella inaequalis", "Type"

Locality: "nova Hollandia"

Current status: *Coelophora inaequalis* (F.): Coccinellidae

Comment: Condition of "type" is fair. It has been pinned twice through the right elytron. The ventral surface is covered with dirt and dried hyphae, the antennae are missing. There are a number of varieties recorded for this species in Junk's Catalogue (idem.). The Fabrician type is taken as the typical structure and is described fully by Mulsant (1850: p.404). The large series in the BMNH collection show considerable variation of markings on thorax and elytra. This species has a wide distribution from Japan and China, through the Malay Archipelago to Tasmania.

INTERRUPTA, Cassida

Fabricius 1775, p. 89, n. 7; 1801, 1, p. 395, n. 40
plasoni Spaeth. 1898, p. 539 *(Aspidomorpha)*
var *badeni* Wgenr. *(Aspidomorpha)*
var *planipennis* Blkb. *(Aspidomorpha)*
Junk's Catal. 1914, 25, 62, p. 71 *(Aspidomorpha)*
Zimsen 1964, p. 90, n. 1309

Holotype labels:
i. Fabricius "Cassida interrupta Fab. Entom. p. 89 n. 7"
ii. BMNH "Cassida interrupta"

Locality: "nova Hollandia"

Current status: *Aspidomorpha interrupta* (F.) Chrysomelidae, Cassidinae

Comment: The holotype is complete except for the terminal joints of the right antenna. The legs are covered in dried mycelial hyphae.

The black markings on the elytra of this species varies as to degree and arrangement.

INTERRUPTUS, Curculio

Fabricius 1781, p. 188, n. 148; 1801, 2, p. 519, n. 70
obliquesignatus Boh. 1842, p. 244
griseus White 1846, p. 14 *(Otiorhynchus)*
apicalis Broun 1881, p. 701 *(Empaeotes)*; loc. cit. 1893, p. 118 *(Platyomida)*
Zimsen 1964, p. 214, n. 3701
Kuschel 1969, p. 789 and pp. 792-5 *(Catoptes)*

Lectotype (Kuschel) labels:
i. Fabricius "Curcul. Interruptus Fabr. Sp. Ins. n. 148
ii. BMNH "Curculio Interruptus", "type"

Locality: Fabricius recorded this specimen from "nova Hollandia". This has proved incorrect as it is from New Zealand (Kuschel idem.).

Current status: *Catoptes interruptus* (F.): Curculionidae, Leptopiinae

Comment: There are two specimens in the Collection. The one that originally had Waterhouse's "type" label is in very poor condition having metathoracic legs and abdomen missing. The "second specimen" is in better condition and has only right metathoracic leg missing. Glue obscures the ventral surface. This specimen is a male and has been designated by Kuschel (idem.) as the lectotype and a label as such has been added to the specimen by R. T. Thompson of the BMNH. The former "type" specimen Kuschel now designates as a paralectotype (1970: p. 204).

There is a female specimen in Fabricius's own collection which Kuschel designates as a paralectotype (Kuschel 1970: p. 204).

G. A. K. Marshall (1944: p. 73) transferred all New Zealand *Catoptes* species from the sub-family Eremninae to the sub-family Leptopiinae.

JESUITA, Apate

Fabricius 1775, p. 54, n. 3; 1801, 2, p. 380, n. 5
canarii Nördl. 1880 App., p. 66
Junk's Catal. 1938, 10, 161, p. 39 *(Bostrychopsis)*
Zimsen 1964, p. 186, n. 3175

Holotype labels:
i. Fabricius "Apate Jesuita Fab. Entom. p. 54 n. 3"
ii. BMNH "Apate jesuita"

Locality: "nova Hollandia"

Current status: *Bostrychopsis jesuita* (F.): Bostrychidae

Comment: Only the metathorax and abdomen of the holotype is left and neither metathoracic leg is complete.

There is another specimen in Fabricius's own collection, now at the Zoological Museum in Copenhagen. This is a well known species and is widely distributed throughout North and South Australia, New South Wales and Victoria. The colour is usually uniformly black, but some specimens may be reddish.

LAETA, Melolontha

Fabricius 1775, p. 36, n. 24; 1801, 2, p. 171, n. 64
Junk's Catal. 1912, 20, 47, p. 90 *(Calonota)*
Zimsen 1964, p. 146, n. 2391

Holotype labels:
i. Fabricius "Melol. laeta Fabr. Sp. Ins. n. 32"
ii. BMNH "melolontha laeta", "type"

Locality: "nova Zelandia"

Current status: *Calonota laeta* (F.) is a variety of *C. festiva* (F.): Scarabaeidae, Melolonthinae.

Comment: The condition of the holotype is fair; both antennae except for two basal joints, tarsi of left prothoracic and right metathoracic legs are missing.

This is a colour variety of *C. festiva* F. It is a pink opalescent colour with red thoracic stripe and red scutellum. Fabricius must have re-examined this species before publishing in 1781 and put this later reference on the label.

LAEVICOLLIS, Silpha

Fabricius 1775, p. 73, n. 7; 1801, 1, p. 338, n. 8
reticulatus Haag 1878, p. 659 *(Saragus)*
Junk's Catal. 1910-11 , 18, 28, p. 424 *(Saragus)*
Zimsen 1964, p. 80, n. 1117
Carter 1926, p. 142

Holotype labels:
i. Fabricius "Silpha laevicollis Fab. Entom. p. 73 n. 7"
ii. BMNH "Silpha laevicollis"

Locality: "nova Hollandia"

Current status: *Celibe laevicollis* (F.): Tenebrionidae, Ulominae

Comment: The holotype is in good condition, only a few tarsi and the right metathoracic leg are missing.

Schenkling in Junk's Catalogue (idem.) incorrectly attributes this species to Olliff, but Carter (idem.) corrects this. This species was formally classified in the genus *Saragus;* Watt (1968: p. 36) made *Saragus* a synonym of the genus *Celibe.*

LAEVIGATUM, Opatrum

Fabricius 1781, 1, p. 90, n. 4; 1801, 1, p. 117, n. 8.
?mauritanicus F. 1792, p. 113 *(Tenebrio)*
piceus Ol. 1792, p. 50
?oryzae Herbst 1799, p. 18
picipes Steph. 1832, p. 11 *(Alphitobius)*
granivorus Muls. et God. 1868, p. 288 *(Alphitobius)*
striatulus Fairm. 1869, p. 231 *(Cataphronetis)*
rufipes Mad. 1872, p. 286 *(Microphyes)*
Zimsen 1964, p. 39, n. 334
Carter 1926, p. 137

Syntype label:
i. Fabricius "Opatrum laevigatum Fab. Sp. Ins. n. 4 Hab. in Nova Zel"
ii. BMNH "Opatrum laevigatum"

There are two specimens under this label, the "type" specimen has the Fabrician label.

Locality: "nova Zelandia"

Current status: *Alphitobius laevigatus* (F.): Tenebrionidae, Ulominae.

Comment: The condition of the "type" is fair, the legs are bunched together and tarsi are missing. This species is not listed by H. Gebien in Junk's Catalogue (1910, 18, 15, p. 458) but the synonym *Microphyes rufipes* Macl. is. This synonymy was identified by Blair (1914: p. 486). The synonyms of this species are listed in Junk's Catalogue as synonyms of *A. piceus* Ol. The distribution of this species is now known to be cosmopolitan.

LEONINA, Coccinella

Fabricius 1775, p. 87, n. 54; 1801, 1, p. 386, n. 160.
tasmanii White 1846, 11, p. 23 *(tasmaniae)*
Junk's Catal. 1931-32, 16, 120, p. 508.
Zimsen 1964, p. 88, n. 1279

Syntype labels:
(i) Fabricius "Cocc. leonina Fab. Entom. p. 87 n. 54"
(ii) BMNH "Coccinella leonina", "Type"

Locality: "nova Hollandia". It is doubtful if this Fabrician locality is correct. Both Mulsant (1850: p. 128) and Schenkling in Junk's Catalogue (idem.) give the locality as New Zealand. Out of twenty specimens in the BMNH collection seventeen have

locality labels as New Zealand. Gemminger et Harold and Masters Catalogues both give the Fabrician locality.

Current status: *Coccinella leonina* F.: Coccinellidae.

Comment: The "type" is in a very poor condition. It has been badly pinned and the specimen is covered with dried fungal hyphae. There is a second specimen which is in much the same condition.

The specimen in the BMNH Collection of the synonym *C. tasmanii* White is labelled "*Coccinella Tasmanii* White, Zool. Ereb. and Terror" (1846: p. 23). The habitat of this specimen is labelled New Zealand. This is probably White's type specimen although it is not labelled as such. In Junk's Catalogue this synonym is incorrectly spelt as *'Tasmaniae'*.

LIMBATUS Dermestes

Fabricius 1781, 1, p. 66, n. 23; 1801, 1, p. 318, n. 36
atomaria Pasc. 1875, p. 210-223
discoidea Pasc. 1875, p. 210-223.
Zimsen 1969, p. 78, n. 1076
Crowson 1964, p. 313 (*Phycosecis*)

Syntype labels:
(i) Fabricius "Dermestes limbatus Fabr. Sp. Ins. n. 23"
(ii) BMNH "Phycosecis limbatus" "Type"

Locality: "nova Zelandia"
Current status: *Phycosecis limbata* (F.): Phycosecidae.

Comment: The "type" is in a very dirty condition, so that it is difficult to determine its structures, especially those of the legs. It is a very small insect and has been pinned through the suture. The head is deflexed sharply. Head is black, main body dark brown and lateral margins of elytra pale testaceous. Prothorax as broad as long, rounded, posterior angles obsolete and anterior angles very acute. Elytra twice length of prothorax, pubescence scanty, punctate and striate. This species is not recorded in Junk's Catalogue, in Broun's manual of New Zealand Coleoptera, nor in Huttons Index Faunae Novae Zealandiae. There is a second specimen. It is in a worse state of preservation than the "type".

LINEATUM, Callidium

Fabricius 1775, p. 189, n. 10; 1801, 2, p. 340, n. 40
australis Gmel. 1790, p. 1849
Junk's Catal. 1912, 22, 39, p. 488 (*Navomorpha*)
Zimsen 1964, p. 179, n. 3036

Holotype labels:
i. "Callid. lineatum Fab. Entom. p. 189 n. 10"
ii. "Callidiam lineatum", "Type"

Locality: "nova Zelandia". Fabricius in 1801 erroneously published the locality as "nova Hollandia". In 1775 the locality is correctly given as "nova Zelandia".

Current status: *Navomorpha lineata* (F.): Cerambycidae, Cerambycinae.

Comment: The holotype is in good condition, only most of the right antenna, and left metathoracic leg are missing. See Broun (1880: p. 590) for detailed description of the species. In Gemminger et Harold Catalogue (1873: p. 2984) the genus is spelt *Naomorpha*.

LINEATA, Lagria

Fabricius 1775, p. 124, n. 3; 1801, 2, p. 68, n. 4 (*Dryops*)
Junk's Catal. 1915, 17, 65, p. 33 (*Sessinia*)
Zimsen 1964, p. 127, n. 2025

Syntype labels:
i. Fabricius "Lagria lineata Fab. Entom. p. 124 n. 3".
ii. BMNH "Dryops lineata", "Type"

Locality: "nova Zelandia"

Current status: *Sessinia lineata* (F.): Oedemeridae.

Comment: The "type" is a female and is in a good state of preservation, the antennae except for basal joint of left antenna and right methatoracic leg are missing. There is a second specimen, it is not in a good condition; it is pinned through the left elytron ⅔ of which is missing, together with both prothoracic legs; not one leg is complete. This species has been recorded under a number of different genera. Fabricius put it in the genus *Dryops* in his later publications. It has also been recorded in the following genera *Oedemera* (Ol. 1794: p. 6), *Sclenopselaphus* (Gemm. et Har. Cat. 1870: p. 2168) and *Thelyphassa* (Blair 1920: p. 153)

LINEOLA F., Coccinella

See *STRIOLA F., Coccinella*
C. lineola F. is a junior homonym

LINEOLA, Curculio

Fabricius 1775, p. 136, n. 48; 1801, p. 503, n. 28 (*Lixus*)
Zimsen 1964, p. 211, n. 3631

Syntype labels:
i. Fabricius "Curc. lineola Fab. Entom. p. 136 n. 48"
ii. BMNH "Lixus lineola", "Type"

Locality: "nova Hollandia"

Current status: *Cossonideus lineolus* (F.): Curculionidae, Cossoninae.

Comment: There are two specimens in the Collection, Zimsen records only one. The specimen with the "type" label is in very poor condition; head and prothorax are intact, but posteriorly it is very badly damaged, only a few remnants of abdomen and elytra remain. The second specimen is in a better condition, only elytra are missing. This species is not listed in Junk's Catalogue. In discussion with E. C. Zimmermann of C.S.I.R.O., Canberra, he placed this species in the genus *Cossonideus.*

LURIDUS, Curculio

Fabricius 1775, p. 138, n. 63; 1801, p. 470, n. 155 *(Rhynchaenus)*
fulginosus Boh. 1835, p. 431 *(Cryptorrhynchus)*
immansuetus Boh. 1837, p. 328 *(Acalles)*
plinthoides Pasc. 1871. p. 199 *(Omydaus)*
Junk's Catalogue 1936, 29, 151, p. 163 *(Omydaus)*
Zimsen 1964, p. 205, n. 3514
Lea 1918, p. 272

Holotype labels:
i. Fabricius "Curc. luridus Fab. Entom. p. 138 n. 63".
ii. BMNH "Rhynchaenus luridus", "type".

Locality: "nova "Hollandia"

Current status: *Omydaus luridus* (F.): Curculionidae, Cryptorrhynchinae

Comment: The holotype is badly abraded, there being no scales present; tarsi of right prothoracic leg and left mesothoracic leg, and the right metathoracic leg are missing.
This species has at times been placed in various genera (Lea idem.). It is now listed in the genus *Omydaus.*

LYNCEA, Saperda

Fabricius 1775, p. 185, n. 8; 1801, 2, p. 323, n. 35
Junk's Catal. 1922, 23, 73, n. 3 *(Xyotoles)*,
Zimsen 1964, p. 175, n. 2964

Holotype labels:
i. Fabricius "Saperda lyncea Fab. Entom. p. 185 n. 8"
ii. BMNH "Saperda lyncea", "Type"

Locality: "nova Zelandia"

Current status: *Xyotoles lynceus* (F.): Cerambycidae, Lamiinae.

Comment: The condition of the holotype is poor; head is covered in dirt; neither antennae is complete, and every leg has parts missing; ventral surface is covered in glue. In the copy of Broun's Manual in the BMNH on p. 593 Dr. Gahan has made a note that White's description (1846: p. 22) which Broun followed "refers to *X. humeratus* Bates, the Fabrician species being wrongly identified by him". Broun does quote a description given by Bates after he, Bates, had examined the Fabrician type, and this is the correct description of *X. lynceus* (F.). *X. lynceus* (F.) is larger than either *X. griseus* (F.) or *X. humeratus* Bates. It is elongate, narrow, sides are nearly parallel along most of entire length of insect, tapering at the apices of elytra; ferruginous, head and prothorax are slightly darker than the rest; prothorax is longer than wide, margined anteriorly, and posteriorly reticulose with an indication of an horizontal anterior and posterior depression; base of elytra is not wider than the prothorax, elytra striate with large scattered punctures on the anterior half, more concentrated towards the base, apices produced and divaricate.

MEDITABUNDUS, Curculio

Fabricius 1775, p. 139, n. 64; 1801, 2, p. 473, n. 169 *(Rhynchaenus)*
monachus Boisd. 1835, p. 430 *(Cryptorrhynchus)*
Junk's Catalogue 1936, 29, 151, p. 241 *(Euthyrhinus)*
Zimsen 1964, p. 206, n. 3526

Holotype labels:
i. Fabricius "Curc. meditabundus Fab. Entom. p. 139 n. 64"
ii. BMNH "Rhynchaenus meditabundus", "Type"

Locality: "nova Hollandia"

Current status: *Euthyrhinus meditabundus* (F.): Curculionidae, Cryptorrhynchinae

Comment: Holotype is in good condition; it has been pinned twice, now through the right elytron but previously through mid-basal line of prothorax. Some authors have spelt the genus *Euthyrrhinus.* Schönherr who named and described the genus (1837: p. 371) spelt it with only one "r". This species is widely distributed throughout the Pacific Islands.

MELANOCEPHALA, Crioceris

Fabricius 1775, p. 119, n. 8; 1801, 1, p. 450, n. 7
Junk's Catal. Suppl. 1973 78, 3, p. 445 *(Synodita)*
Zimsen 1964, p. 102, n. 1544

Holotype labels:
i. Fabricius "Crioc. melanocephala Fab. Entom. p. 119 n. 8"
ii. "Crioceris melanocephala", "Type"

Locality: "nova Hollandia"

Current status: *Synodita melanocephala* (F.): Chrysomelidae, Galerucinae.

Comment: The condition of the holotype is poor; glue obscures much of the ventral surface. The right

antenna, parts of the left antenna and metathoracic legs, half of the elytron and the abdomen are missing. J. A. Wilcox gives a full list of references in Junk's Catal. Suppl. (idem.). The colour of the elytra of this species varies from metallic green-blue to violet-blue. The elytra of the holotype is violet-blue, but rather faded with age.

MINUTA, Apate

Fabricius 1775, p. 54, n. 4; 1801, 2, p. 383, n. 25
substriatus Staph 1839, p. 352
vertens Walk. 1859, p. 260
siculus Baudi 1873, p. 336
bifoveolatus Zoufal 1894, p. 42
'japonicus Matsum. 1915, p. 184
Junk's Catal. 1938, 10, 161, p. 24
Zimsen 1964, p. 187, n. 3192

Locality: "nova Zealand"

Current status: *Dinoderus minutus* (F.): Bostrychidae

Comment: Specimen under this label in the Bank's Collection is not *Apate minuta* F. but is a species of *Sinoxylon*. C. Waterhouse recognised this was not the type of *A. minutus* F. and has added a label "This cannot be the type." There is no specimen of this species in Broun's collection but there is a space left for it. P. Lesne (1897: p. 329) in his revision of this group records this species as being cosmopolitan but does not record New Zealand as one of the countries where it has been found. There is a large series in the BMNH showing its wide distribution.

MINUTUM, Anobium

Fabricius 1781, 1, p. 72, n. 8; 1781 Spec. Ins. App., p. 499, n. 13-14 *(Lagria)*; 1792, 2, p. 81, n. 17 *(Lagria)*; 1801, 2, p. 74, n. 12 *(Dasytes)*
subcyaneus Broun 1880, p. 328 *(Dasytes)* new synonym.
Junk's Catal. 1937, 10, 155, p. 75 *(Dasytes)*
Zimsen 1964, p. 129, n. 2051

Syntype labels:
i. Fabricuis "Lagria Minuta Fabr. Sp. Ins. App. p. 499 n. 13-14"
ii. BMNH "Dasytes minuta", "Type"

Locality: "nova Zelandia"

Current status: *Dasytes minutus* F. Melyridae (Dasytidae)

Comment: The "type" is in very poor condition, pinned through the left elytron, structures appear to be complete but the specimen is very dirty and covered with mycelium. The second specimen is also pinned through the left elytron and is badly damaged with head and prothorax missing. The Fabricius reference on the label is not recorded by Pic in Junk's Catalogue nor by Zimsen. It appears that when compiling the Species Insectorum Fabricius put this species into the genus *Anobium*, then, presumably after re-examination changed the genus to *Lagria* and published this in the Appendix. In 1792 he still published it under the genus *Lagria* but in 1801 put it in the genus *Dasytes*, the genus in which it is now stands. Pic (idem.) records *D. minuta* F. with the earliest reference but gives the incorrect page number of 79 which should be 72. Page 79 is the reference for the species *Sphaeridium minuta* F. *D. minuta* F. does not appear in Broun's manual (1880), nor in Hutton's Index Fauna Novae Zelandia (1904). Broun (1880 p. 328) describes *D. subcyaneus* as a new species. This account decribes the Fabrician type of *D. minuta* F, and on comparison *D. subcyaneus* Broun proves to be a synonym of *D. minuta* F. Pic. (idem.) lists them as separate species.

MINUTUM, Callidium

Fabricius 1775 p. 192 n. 23; 1801, 2 p. 346, n. 2 *(Clytus)*
exiguum Gmel. 1788 p. 1852, *(Zorion)*
fabricianum Westw. *(Obrium)* 1845, p. 28.
Junk's Catal. 1912, 22, 39, p. 156 *(Zorion)*
Zimsen 1964, p. 180, n. 3061.

Holotype labels:
i. Fabricius "Callid Minutum Fab. Entom. p. 192, n. 23"
ii. BMNH "Clytus minutus", "Type"

Locality: "nova Zelandia"

Current status: *Zorion minutum* (F.): Cerambycidae, Cerambycinae

Comment: The holotype is badly damaged, right elytron is almost detached, except for 3 basal joints of left antenna and abdomen are missing, and right metathoracic leg is detached. See Broun (1880: p. 584) for detailed description. Fabricius himself reclassified this specimen in 1801 into the genus *Clytus*.

MODESTA, Curculio

Fabricius 1781, p. 186, n. 138; 1801, 2, p. 512, n. 30
brevipennis Broun 1880, 1, p. 438 *(Cecyropa)*
maritima Broun 1880, 1, p. 438 *(Cecyropa)*
alba Broun 1881, 2, p. 698 *(Cecyropa)*
varia Broun 1881, 2, p. 698 *(Cecyropa)*
albicans Sharp 1886, 2, 3 p. 416 *(Cecyropa)*
macularia Broun 1886, 4, p. 961 *(Cecyropa)*
lineifera Broun 1903, 7, 12 p. 72 *(Cecyropa)*
alternata Broun 1904, 7, 14, p. 105 *(Cecyropa)*
dicors Broun 1904, 7, 14, p. 106 *(Cecyropa)*
striatella Broun 1917, 1, 5, p. 399 *(Cecyropa)*
jucunda Broun 1917, 1, 5, p. 400 *(Cecyropa)*
laticollis Broun 1917, 1, 5, p. 400 *(Cecyropa)*

Zimsen 1964, p. 213, n. 3670
Kuschel 1969, p. 789 and p. 807; 1970, p. 205 *(Cecyropa)*

Holotype labels:
i. Fabricius "Curc. Modestus Fabr. Sp. Ins no. 138"
ii. BMNH "Curculio modestus", "Type"

Locality: "nova Zelandia"

Current status: *Cecyropa modesta* (F.): Curculionidae, Rhyparosominae

Comment: Holotype a male, is very dirty; parts of all legs are missing. This species was omitted from recent catalogues. G. Kuschel describes and discusses this species and its synonyms fully. Zimsen records that there are 2 specimens in BMNH. There is only one, therefore it is the holotype.

MONTICOLA, Melolontha

Fabricius 1775, p. 39, n. 38; 1801, 2, p. 184, n. 138
Junk's Catal. 1912, 20, 47, p. 96 *(Liparetrus)*
Zimsen 1964, p. 150, n. 2460

Holotype labels:
i. Fabricius "Melol. monticola Fabr. Sp. Ins. n. 67"
ii. BMNH "Melolontha monticola", "Type"

Locality: "nova Hollandia"

Current status: *Liparetrus monticolus* (F.): Scarabaeidae, Melolonthinae.

Comment: The condition of the holotype is fair; but for the legs which are missing except for a few remains lying in the glue. In Junk's Catalogue Dalla Torres records this Fabrician species, but all earlier references until Macleay's publication in 1886, query the author of this species, though there is a labelled 'type' specimen in the Banks' Collection. Blackburn (1905: p. 315) states that the two badly broken specimens in the Macleay Museum labelled as "monticola Fab." are incorrectly labelled. The specimens are two distinct species and one is labelled elsewhere in the same collection as *L. atriceps* Macl. and are not *L. monticolus* (F.). There are two specimens labelled *L. atriceps* Macl. in the BMNH but these are distinct from the Fabrician type *L. monticolus* (F.). *L. monticolus* (F.) is smaller than *L. sylvicolus* (Fab.), but they are closely related, punctation on prothorax and striation and punctuation on elytra is very similar. This species must have been re-examined by Fabricius as the label has the later reference 1781.

MORIO, Chrysomela

Fabricius 1787, 1, p. 66, n. 2; 1801, 1, p. 424, n. 5
Junk's Catal. 1924, 24, 68, p. 161 *(Paropsisterna)*
Zimsen 1964, p. 96, n. 1425

Syntype labels:
i. Fabricius "Chr. Morio Fabr. Mant. Ins. n. 2"
ii. BMNH "Chrysomela morio", "Type"

Locality: "terra Diemenii"

Current status: *Paropsisterna morio* (F.). Chrysomelidae Chrysomelinae

Comment: The condition of the "type" is fair, parts of the antennae and tarsi of the right metathoracic leg, which is detached and lying in the glue, are missing. There is a second specimen which is in very good condition, all parts are complete. In this species there is a good deal of colour variation from pitch black to dark ferruginous or reddish. The type is black with brownish antennae, while the second specimen has a reddish colouration. Specimens from New South Wales, Tasmania and South Australia in the large series in the BMNH collection show the same variation in colour. They also show variation in the punctation of the elytra. It is possible that there is more than one species or variety under this label. Blackburn (1898: p. 225) describes this species in detail but states that the punctures on the elytra "are fine, finer than those of *P. rubrosignata* Boh. and *P. sexpustulata* Marsh. *P. rubrosignata* Boh. is now regarded as a synonym of *P. beta* Newm. In the Fabrician type, however, the punctures are stronger and coarser than in either of those species.

MORIO, Erotylus

Fabricius 1775, p. 123, n. 4; 1801, 2, p. 19, n. 14 *(Cistela)*
fovea-seriatus Fairm. 1877 p. 187 *(Amarygmus)*
curvipes Geb. *(alienus* Blk. nom. praeocc. 1893 p. 89 and 93) *Amarygmus)*
var. *uniformis* Blk. 1889, p. 1272 and 1893, p. 93 *(Amarygmus)*
var. *tasmanicus* Blk. 1893, p. 105 *(Amarygmus)*
Zimsen 1964, p. 117, n. 1825
Carter 1913, p. 37 and 1926, p. 158

Holotype labels:
i. Fabricius "Erotylus morio Fab. Entom. p. 123 n. 4"
ii. BMNH "Cistela morio", "Type"

Locality: "nova Hollandia"

Current status: *Amarygmus morio* (F.): Tenebrionidae, Amarygminae.

Comment: The holotype is in a poor state of preservation. It has been broken between the pro and mesothorax and glued together again; glue obscures most of the ventral surface; all legs, except for the left metathoracic leg, are damaged and parts

missing. Carter (1913, p. 6) discusses the synonymy of this species and on page 35 he quotes a letter from Blair of the BMNH describing how the Fabrician type was so dirty the colouration was completely obscured but after cleaning the true colours were revealed. Fabricius (1775; p. 123) describes the colour as "ater" (dull black), this must have been due to the dirty state of the specimen which he must have described without cleaning it. This species as Carter notes was omitted from the catalogues.

MYSTACINA, Hispa

Fabricius 1775, p. 70, n. 1; 1801, 1, p. 328, n. 1 *(Ptilinus)*
Junk's Catal. 1925, 11, 81, p. 6 *(Rhipicera)*
Zimsen 1964, p. 79, n. 1102

Holotype labels:

i. Fabricius "Ptil. Mystacinus" written on the underside of the label. "Derm. navalis Fab. Entom. p. 56 9" was originally written on the label but has been crossed out. The writing on both sides of the label is the same and appears to be that of Fabricius.

ii. BMNH "Ptilinus mystacinus" and the register number 63-46.

Locality: "nova Hollandia"

Current status: *Rhipicera mystacina* (F.): Rhipiceridae.

Comment: Holotype is in good condition, most of the left antenna is missing and also tarsi of the left metathoracic leg. This was one of the specimens Fabricius must have re-examined during his later visit to London. By then, he had studied many more species and had created new genera as his knowledge of insects increased. Therefore we find that this species is no longer in the genus *Hispa* but is put in the genus *Ptilinus* and is published as such in 1801. How the label of *Dermestes navalis F.* came to be on this specimen we do not know. As the "type" of *D. navalis* F. was evidently missing when Fabricius made his last study of the Banks Collection, he meant only to use this label temporarily when he changed the generic name of *H. mystacinus* F.

NAVALIS, Dermestes

Fabricius 1775, p. 546, n. 9; 1801, 1 p. 155, n. 23 *(Lyctus)*
Junk's Catal. 1910-11, 18, 28, p. 395 *(Tribolium)*
Zimsen 1964, p. 48, n. 497

Locality: "nova Zelandia"

Comment: Zimsen records "D. navalis in Nova Hollandia, Mus D. Banks, type lost". The 1775 reference is given in which the habitat is "nova Zelandia". Zimsen records that *D. navalis* F. is a synonym of *Tenebrio ferrugineus* F. the locality of which is given as "African aequinoctali" and the type as being in Mus. Dom. Banks."

In the Fabricius reference 1801, 1, p. 155 n. 23 for *Trogosita ferruginea* there are two synonyms listed—*Ips testacea* Ent. Syst. Suppl. p. 179 n. 14 and *Lyctus navalis* Ent. Syst. 1, 2 p. 504 n. 10 and the "habitat" is given as "India utrague". In Junk's Catalogue (idem) *Tenebrio ferrugineus* F. is listed under the generic name of *Tribolium* with the reference Mant. Ins. 1787, 1 p. 212. Zimsen gives an earlier reference still for this species, Spec. Ins. 1781, 1 p. 324. In Junk's Catalogue *T. navale* Herbst (1792: p. 138) is listed as a synonym of *T. ferrugineus* F., but in the index of the catalogue *T. navalis* is correctly attributed to Fabricius. K. G. Blair (1913: p. 222) proposed the generic name of *Triboloides* for *T. ferrugineus* F.

The "Type" of *D. navalis* F. has recently been found in the Hunterian Collection in Glasgow. It is in a poor state of preservation and is carded in a larged amount of glue. See Introduction (p. 157).

NIGRICORNIS, Chrysomela

Fabricius 1775, p. 98, n. 20; 1801, 1, p. 435, n. 79
Junk's Catal. 1924, 24, 68, p. 201 *(Phyllocharis)*
Zimsen 1964, p. 99, n. 1485

Holotype labels:

i. Fabricius "Chrys. Nigricornis Fab. Entom. p. 98, n. 20".

ii. BMNH "Chrysomela nigricornis", "Type"

Locality: "nova Hollandia"

Current status: *Phyllocharis nigricornis* (F.): Chrysomelidae, Chrysomelinae.

Comment: The condition of the "type " specimen is fair. It has been pinned twice through the right elytron which is cracked. The antennae are missing except for the basal joint of the right one, the left metathoracic leg is also missing. The condition of the second specimen is much the same as that of the "type" only the left antenna is complete, and the left not the right metathoracic leg is missing. There is a marked variation in colour and size of the ferrugineous spots in this species. The "type" is brassy-black; head ferrugineous with a black frontal patch, antennae black; thorax brassy-black with ferrugineous lateral margins; elytra finely punctuated, brassy-black with two ferrugineous humeral spots placed obliquely; abdomen blue-black, base and apex ferrugineons. Baly (1855: p. 175) in his discussion of this genus described a new species *P. cyannipennis,* but realised that it was "very closely allied" to *P. nigricornis* (F.). Baly's type in the BMNH Collection is labelled *P. nigricornis* (F.)

Weise in Junk's Catal. (idem) lists *P. cyannipennis* Baly as a variety of *P. cyanipes* (F.).

A study of the large series of this genus in the BMNH Collection showed that there are a great many variations in colour and colour patterns, often one grading into another. It seems likely that there are a number of geographical subspecies or varieties of the different species which have yet to be worked out.

In the second specimen in the Banks Collection there is a ferrugineous apical spot as well as the two humeral spots on the elytra. Fabricius in his original (1775) description does not mention this so the specimen labelled "Type" by C. O. Waterhouse must be the holotype. Fabricius' description is "C. ovata, nigro-aenea, capite, thoracis lateribus elytrorumque macula duplici, baseos ferrugineis"—an oval *Chrysomela*, brassy-black, head, sides of thorax, two spots on elytra, base ferrugineous.

NIGRIPES, Crioceris (Lema)

Fabricius 1775, p. 120, n. 14; 1801, 1, p. 476, n. 30 *(Lema)*
australis Jac. 1876, p. 807 and 1878, p. 152
Junk's Catal. 1924, 24, 51, p. 48
Zimsen 1964, p. 107, n. 1646

Syntype labels:
i. Fabricius "Crioceris nigripes Fab. Entom. p. 120, n. 14".
ii. BMNH "Lema nigripes", "Type"

Locality: "nova Hollandia"

Current Status: *Crioceris nigripes* F.: Chrysomelidae, Criocerinae.

Comment: The condition of the "type" is good and all structures are complete but meso and metathoracic legs are entangled in glue. The condition of the second specimen is much the same, but the ventral surface is not so clean. Fabricius reclassified this species into the genus *Lema* in the 1801 publication but since then it has been restored to original genus. Zimsen only records one specimen as being in the collection.

NOVAEHOLLANDIAE, Scarabaeus

Fabricius 1775, p. 29, n. 113; 1801, 1, p. 57, n. 15 *(Ateuchus hollandiae)*
hollandiae F. 1781, 1, p. 32;
piceum Hope 1841, p. 44 *(Tesserodon)*
Junk's Catal. 1911, 19, 38, p. 40 *(Tesserodon)*
Zimsen 1964, p. 30, n. 173
Matthews 1974, p. 87 *(Tesserodon)*

Holotype labels:
i. Fabricius "Scarab. N. Hollandiae" Fabr. Sp. Ins. No. 144.
ii. BMNH "Ateuchus N. Hollandiae"

Locality: "nova Hollandia"

Current status: *Tesserodon novaehollandiae* (F.): Scarabaeidae, Scarabaeinae.

Comment: The specimen is very dirty. C. O. Westwood found this type specimen among the unarranged specimens in the last drawer of the Bank's Collection. The reference on the label is the 1781 reference indicating that Fabricius re-examined this specimen in 1780-1. In this reference Fabricius omitted the N. for "nova", although it is on his label, and gave the specific name as *Scarab. hollandiae*. This was copied in his later publications and in later catalogues. The valid name now is *T. novaehollandiae* (F.).

NOVEMMACULATA, Coccinella

Fabricius 1775, p. 81, n. 15; 1781, 1, p. 97, n. 26; 1801, 1, p. 366 and 61.
novempunctate F. 1775, p. 81;
picta Muls. Voet. 1796, p. 61 *(Coelophora)*
Junk's Catal. 1931-32, 16, 120, p. 294 *(Coelophora)*
Zimsen 1964, p. 85, n. 1212

Holotype labels:
i. Fabricius "Coccinella 9-maculata Fabr. Spec. 97 n. 26"
ii. BMNH "Coccinella 9-maculata"

Locality: "nova Hollandia". This species has been recorded from the Philippines and Indonesia, not from Australia. It is probable that the "type" was collected in Java, as Banks collected at Batavia when the *Endeavour* stopped there for some weeks for repairs.

Current status: *Coelophora novemmaculata* (F.) synonym *C. novempunctata* (F.). Coccinellidae, Coccinellinae

Comment: Holotype has been badly pinned through left elytron, and there is a great deal of glue on ventral surface obscuring most of the abdomen and entangling the metathoracic legs. The right membranceous wing is unfolded and lying out beyond the elytra. The apical segments of both antennae, the right prothoracic leg and the terminal tarsi of the right mesothoracic leg are missing. Musgrave (1932: p. 87) in his listings of Fabrician types from "nova Hollandia" recorded in the Species Insectorum (1781), states, *C. 9-maculata* (1781: 1, p. 97) nom. nov. for *Cocc. 9-punctata* Fab. preoccupied by *Cocc: 9-punctata* Linne 1758". Fabricius, however, although changing the specific name, continued to publish both names in the publication 1781, and in 1787 and 1801 as separate species. Although the Linnean and Fabrician species are now in different genera, the valid name for the Fabrician species is *C. novemmaculata* F. according to the International Code. There is no specimen in

the Bank's Collection labelled 9-punctata F. The type is marked with two median dark brown or black spots on the thorax. There is no basal black line nor is the sutural margin black. There are four black spots on each elytron and one posterior spot which is divided so that one half lies on each elytron.

NOVEMPUNCTATA, Coccinella

See *NOVEMMACULATA, Coccinella*

C. novempunctata is the junior homonym.

OBSCURUM, Callidium

Fabricius 1787, 1, p. 151, n. 1; 1801, 2, p. 333, n. 1.
lentiginosus Newm. 1841, p. 7 *(Phacodes)*
Junk's Catal. 1912, 22, 39, n. 70 *(Phacodes)*
Zinsen 1964, p. 178, n. 3008
McKeown 1947, p. 22

Syntype labels:
i. Fabricius "Call. obscurum Fabr. Mant. Ins. n. 1".
ii. BMNH "Callidium obscurum", "Type"

Locality: "terra Diemenii"

Current status: *Pachydissus obscurus* (F.): Cerambycidae, Cerambycinae

Comment: The condition of the "type" is good. There is a second specimen, which is very dirty; terminal joints of antennae, left metathoracic leg and all tarsi are missing. This large well known insect has a wide distribution throughout Tasmania, South and Eastern Australia.

OCTODECIMGUTTATA, Chrysomela

Fabricius 1775, p. 100, n. 31; 1801, 1, p. 439, n. 101.
keyserlingi Ws. *(Phola)*
sedecimpustulata Stal. *(Phyllophila)*
Junk's Catal. 1924, 24, 68, p. 199 *(Chalcolampra)*
Zimsen 1964, p. 99, n. 1502

Syntype labels:
i. Fabricius "Chrys. 18-Guttata Fab. Entom. p. 100 n. 31"
ii. BMNH "Chrysomela 18-guttata", "Type"

Locality: "nova Hollandia"

Current status: *Chalcolampra octodecimguttata* (F.): Chrysomelidae, Chrysomelinae.

Comment: The specimen labelled "Type" is not in good condition; ventral surface is in a bad state of preservation; right antenna and all but five joints of left antenna, tarsi of left mesothoracic and right metathoracic legs are missing. The condition of the second specimen is not as good as the "type". Baly (1855: p. 186) described this species and put it into its present genus. He notes that there are eight not nine spots on the elytra. The depth of colour of this species varies considerably, and the elytral spots may or may not be distinct. These spots are arranged in two longitudinal lines. On examination of the large series in the BMNH it is seen that these spots may or may not coalesce. In the "type" the spots in the outer or marginal line have coalesced and therefore definition of the actual number of spots is obscure. The prothorax in this species varies in colour from dark ferrugineous to pale, with or without three black spots arranged medianly in the form of an inverted triangle, as it is in the "type".

OCULATA, Crioceris

Fabricius 1775, p. 121, n. 15 *(C. oculata);* 1801, 1, p. 458, n. 43
sculpta Blkb 1890, p. 363 *(Candezea)*
Junk's Catal. Suppl. 1973, 78, 3, p. 580 *(Monolepta)*
Zinsen 1964, p. 103, n. 1578

Syntype labels:
i. Fabricius "Crioc. oculata Fab. Entom. p. 121 n. 15"
ii. BMNH "Crioceris oculata", "Type"

Locality: "nova Hollandia"

Current status: *Lema oculata* (F.): Chrysomelidae, Criocerinae.

Comment: The condition of the "type" is poor, mainly due to the presence of a large amount of glue on the ventral surface. Right antenna and terminal joints of the left antenna, the right prothoracic leg except for coxa, tarsi of the left metathoracic leg and the right metathoracic leg are missing. The condition of the 2nd specimen is also in a very poor state, both antenna and all legs are missing.

In Junk's Catal. (1924, 24, 51, p. 72) this species was incorrectly attributed to Olivier (1791: p. 200). Fabricius's later references are given but not the original (1775) one. Olivier attributes it to Fabricius and gives the original reference in which the name of the species is spelt *oculatata.* Fabricius himself changed the spelling to *oculata,* "a justified emendation", first, in his Species Insectorum (1781) and then in his later publications.
N.B. Wilcox in Junk's Catalogue Suppl. (idem.) gives full references and synonyms.

OCULATUS, Staphylinus

Fabricius 1775, p. 265, n. 4; 1801, 2, p. 592, n. 2
Junk's Catal. 1914, 5, 57, p. 399 *(Creophilus)*
Zimsen 1964, p. 230, n. 3982
Steel 1949, p. 59

Syntype labels:
i. Fabricius "Staphyl. oculatus Fab. Entom. p. 265 n. 4"

ii. BMNH "Staphylinus oculatus", "Type"

Locality: "nova Hollandia et Zelandia"

Current status: *Creophilus oculatus* (F.): Staphylinidae, Staphylininae.

Comments: "Type", a male, has been pinned twice, previously through the base of the prothorax and now through the right elytron; terminal joints of right antenna are missing, membranous wings are unfolded and extend out beyond the abdomen.

Second specimen, a female, is pinned through the left elytron, terminal joints of both antennae and tarsi of right metathoracic leg are missing, prothoracic legs are immersed in glue and membranous wings are unfolded.

See W. O. Steel (idem.) for description of this species and table of Australian species of this genus.

PEDICORNIS, Lamia

Fabricius 1775, p. 170, n. 1; 1801, 2, p. 282, n. 4
tuberculata Hope 1841, p. 49 *(Rhytophora)*
obscura Breuning 1938, p. 363 *(Saperdopsis)*
bispinosa Breuning 1938, p. 364 *(Saperdopsis)*
Junk's Catal. 1922-23, 23, 73, p. 267 *(Platyomopsis)*
Zimsen 1964, p. 167, n. 2784
McKeown 1947, p. 153

Holotype labels:
i. Fabricius "Lama pedicornis Fab. Entom. p. 170 n. 2"
ii. BMNH "Lamia pedicornis", "Type"

Locality: "nova Hollandia"

Current status: *Platyomopsis pedicornis* (F.): Cerambycidae, Lamiinae.

Comment: The holotype condition is fair; terminal joints of both antennae and tarsi of left metathoracic leg are missing, right metathoracic leg is detached and lying in the glue.

PORCATUS, Carabus

See *PORCULATUM, F., Calosoma*

C. porcatus. F. is the junior homonym.

PORCATUS, Notoxus

Fabricius 1787, 1, p. 127, n. 1; 1801, 1, 287, n. 1
cribricollis Spin. 1844, p. 203 *(Natalis)*
var *inconspicus* Blk. 1890, p. 124 *(Natalis)*
Junk's Catal. 1910, 10, 23, p. 37 *(Eunatalis)*
Zimsen 1964, p. 72, n. 965

Holotype labels:
i. Fabricius "Not. Porcatus I. Mant. n. 1"
ii. BMNH "Notoxus porcatus"

Locality: "terra Diemenii"

Current status: *Eunatalis porcata* (F.): Cleridae

Comment: The type has been badly pinned once through the prothorax and once through the right elytron. The specimen has been broken between the pro and mesothorax and then glued together, the glue spreading over parts of the elytra and ventral structures. Both head and legs are covered with dirt. This specimen would have been collected by David Nelson who travelled with Cook on his third voyage when the *Discovery* called in at Adventure Bay, Tasmania.

PORCULATUM, Calosoma

Fabricius 1775, p. 239, n. 16 *(Carabus porcatus)*; 1801, 1, p. 211, n. 3
porcatus F. 1775, p. 239.
caraboides Kirby 1818, p. 466. *(Adelium)*
Junk's Catal. 1911, 18, 28, p. 510 *(Adelium)*
Zimsen 1964, p. 60, n. 727
Carter 1926, p. 154

Holotype labels:
i. Fabricius "Carabus porcatus Entom. p. 239 n. 16"
ii. BMNH "Carabus porcatus" A later label has been added "Tenebrionid".

Locality: "nova Hollandia"

Current status: *Adelium porculatum* (F.): (Tenebrionidae, Ulominae.

Comment: The holotype is pinned through the left elytron which is cracked. Glue conceals most of the right metathoracic leg. Neither antenna is complete, 3 joints are missing of the left antenna, and 5 from the right one. Most tarsi are missing and remnants of the left meso and metathoracic legs are lying in the glue. E. Zimsen lists *Calosoma porculatum* F. with the 1801 reference as a synonym. In this reference Fabricius lists the name *C. porcatus* as the synonym with the reference of Ent. Supt. 1792, 1, p. 147. Fabricius himself changed the original name *porcatus* to *porculatum* in 1801 and this now stands as the valid name according to the International Code.

QUADRIDENS, Curculio

Fabricius 1775, p. 153, n. 139; 1801, 2, p. 536, n. 175
Junk's Catal. 1931, 28, 114, p. 21 *(Leptops)*
Zimsen 1964, p. 219, n. 3787

Holotype labels:
i. Fabricius "Curc. 4-dens Fab. Entom. p. 153 n. 139
ii. BMNH "Curculio 4-dens"

Locality: "nova Hollandia"

Current status: *Leptopius* (Oke 1951) *quadridens* (F.): Curculionidae, Leptopiinae.

Comment: The condition of the "type" is good. There is a second specimen minus its head and prothorax so I have designated the better specimen as a holotype rather than a syntype. There is a large series in the BMNH under the label *L. quadridens* (F.). However, these specimens were considered by G. J. Arrow in 1929 to have been incorrectly identified. The posterior region of the elytra in the Fabrician type is vertically declined, while in all the above-mentioned specimens it is not nearly so abruptly declined.

QUADRIPUNCTATA, Galleruca

Fabricius 1775, p. 112, n. 4 *(Altica albicollis);* 1801, 1, p. 499, n. 110
albicollis F. 1775, p. 112 *(Altica)*
splendidus Jac. 1885, p. 928 *(Licyllus).* Synonymy after Bryant 1923, p. 143
Junk's Catal. 1940, 25, 166, p. 7 *(Licyllus)*
Zimsen 1964, p. 113, n. 1748

Holotype labels:
i. Fabricius "Altica Albicollis Fab. Entom. p. 112, n. 4"
ii. BMNH "Crioceris albicollis", "Type"

Locality: "nova Hollandia"

Current status: *Licyllus quadripunctata* (F.): Chrysomelidae, Halticinae.

Comment: The "type" is in a poor state of preservation. It is a very small insect and has been pinned twice, formerly through the right elytron and now through the suture; left elytron, right and left antennae except for basal joints, tibiae and tarsi of metathoracic legs are missing. Fabricius re-classified this species into the genus *Galleruca* (1792: p. 29) and in 1801 he changed the specific name to *4-punctata* due to the pre-occupation of the specific name *albicollis* which he had given to a Brazilian species. Though both species are now in different genera, according to the International Code *quadripunctata* is the valid name.

QUADRIPUSTULATUM, Sphaeridium

Fabricius 1775, p. 67, n. 6; 1801, 2, p. 575, n. 2 *(Scaphidium)*
bimaculatum Macl. 1864, p. 119 *(Scaphidium)*
Junk's Catal. 1910, 8, 13, p. 8 *(Scaphidium)*
Zimsen 1964, p. 229, n. 3943
Löbl 1976, p. 287-8

Holotype labels:
i. Fabricius "Sphaerid 4-pustulatum Fab. Entom. p. 67-6"
ii. BMNH "Type"

Locality: "nova Hollandia"

Current status: *Scaphidium quadripustulatum* (F.): Scaphidiidae

Comments: Holotype is a male, synonym *bimaculatum* Macl. is a female. The condition of the holotype is fair, both antennae and mesothoracic legs is are missing. It seems that when the Bank's Collection was arranged in the order of that in Systema Eleutheratorum this specimen was not included. Later it must have been discovered, perhaps in the last drawer among the unnamed specimens by C. O. Waterhouse when he was adding type-labels to the collection and as the label is *Sphaeridium 4-pustulatum* he put it in that genus and added a type-label to it but no other BMNH label. In 1929 when I was studying the collection K. G. Blair of the BMNH placed it in its correct position according to the order in the Systema Eleutheratorum.

E. Csiki in Junk's catalogue (idem) and in some literature it has been attributed to Olivier. This is incorrect and has been corrected by Y. Löbl (idem) in his revision of the Australian species of *Scaphidium.*

QUADRIPUSTULATUS, Scarabaeus

Fabricius 1775, p. 27, n. 107; 1801, 1, p. 53, n. 105 *(Copris)*
bipustulatus F. 1775, p. 30
albertisi Harold 1877, p. 71 *(Onthophagus)*
minusculus Macleay 1888, p. 903 *(Onthophagus)*
Junk's Catal. 1927, 19, 90, pp. 215 *(Onthophagus)*
Zimsen 1964, p. 29, n. 155
Matthews 1927, p. 220 *(Onthophagus)*

Holotype labels:
i. Fabricius "Scarab. 4-pustulatus Fabr. Sp. Ins. No. 137"
ii. BMNH "Copris 4-pustulatus", "Type"

Locality: "nova Hollandia"

Current status: *Onthophagus quadripustulatus* (F.): Scarabaeidae, Scarabaeinae.

Comment: The holotype is badly pinned; head is sharply deflexed, right elytron and meso and metathoracic legs are detached and lying in glue. The club of the left antenna and some tarsi are missing. The reference on the label is the 1781 reference indicating that Fabricius re-examined this specimen in 1780-1. *O. bipustulatus* (F.) is the female of *O. quadripustulatus* (F.) (Matthews idem).

RUFIPES, Gyrinus

see *AUSTRALIS, Gyrinus*

G. rufipes F. is a synonym of *G. australis* F.

RUFIPES, Helops

Fabricius, 1775, p. 258, n. 5; 1801, 1, p. 161, n. 34.
australis Boisd 1835, p. 282 *(Allecula)*
angusticollis Boh. 1858, p. 100 *(Allecula)*
Carter 1915, p. 79, and 1930, p. 269
Zimsen 1964, p. 50, n. 531

Holotype labels:
i. Fabricius "Helops rufipes Fab. Entom. p. 258 n. 5"
ii. BMNH "Helops rufipes" and the BMNH register number 63/46

Locality: "nova Hollandia"

Current status: *Homotrysis rufipes* (F.): Alleculidae

Comment: Holotype has been broken between meso and metathorax and badly glued together again so that the anterior part is lying at an angle to the posterior region. The terminal joints of the antennae are missing and the right antenna is detached and lying in the glue. H. J. Carter (idem.) established that *Allecula angusticollis* Boh. is a synonym. Blair (1920: p. 154) referring to this synonym notes that "this is another name *(H. rufipes F.)* that seems to have disappeared from recent catalogues".

SANGUINIPES, Tenebrio

Fabricius 1775, p. 256, n. 7; 1801, 1, p. 148, n. 20
consentanea Perroud 1864, p. 119
depressa Pasc. 1886, p. 454
laticornis Pasc. *(Achthosus)* 1869, p. 294
Carter 1926, p. 137
Zimsen 1964, p. 46, n. 474

Holotype labels:
i. "Fabricius Tenebrio sanguinipes Fab. Entom. p. 256, n. 7"
ii. BMNH "Tenebrio sanguinipes" and the register number 63/46 and "Type"
iii. Achthosus laticornis Pasc.

Locality: "nova Hollandia"

Current status: *Uloma sanguinipes* (F.): Tenebrionidae, Ulominae

Comment: The condition of the holotype is poor. It has been broken and glued together at the junction of the meso and metathorax. All legs on left side are missing. The holotype is a female and differs from the male described by Pascoe (idem.) as *Achthosus laticornis* in that the prothorax has no excavation, the anterior tibiae are without internal emargination and it is smaller in size. *U. sanguinipes* (F.) is not listed by H. Gebien in Junk's Catalogue but it is in Carter's check list (idem.) together with its synonyms.

SCABER, Dermestes

Fabricius 1775, p. 57, n. 16; 1801, 1, p. 318, n. 32
integer Sharp *(Ulonotus)*, new synonym
Junk's Catal. 1930, 15, 107, p. 39 *(Ulonotus)*
Zimsen 1964, p. 77, n. 1073

Holotype labels:
i. Fabricius "Derm. Scaber Fab. Entom. p. 57, n. 16"
ii. BMNH "Dermestes scaber"

Locality: "nova Zelandia"

Current status: *Ulonotus scaber* (F.): Colydiidae

Comment: Specimen is very dirty and pinned badly through left elytron. Hope (1840: p. 145) created a new genus *Pristoderus* for this species. However, both Lacordaire (1854, p. 359 nota) and Sharp (1876, p. 17) state that this name should be dropped as the description given by Hope was insufficient for indentification. The species is now classified in the genus *Ulonotus* Er. see Junk's Catalogue (idem.). A. Hetschko in Junk's Catalogue lists *U. integer* Sharp (1877, p. 268) as a separate species. Sharp's type is in the BMNH on comparing this type with *D. scaber* F. it is found to be synonymous with it. This is a new synonym.

SCUTELLARIS, Curculio

Fabricius 1781, 1, p. 115, n. 196; 1801, 2, p. 519, n. 71
exsertus F. 1801, 2, p. 534, n. 163
var. *murinus* Lea 1911, p. 63 *(Prypnus)*
Junk's Catal. 1939, 27, 164, p. 259 *(Prostomus)*
Zimsen 1964, p. 215, n. 3702

Holotype labels:
i. Fabricius "Curc. Scutellaris Fabr. M. Ins. n. 196"
ii. BMNH "Curculio scuterllaris", "Type"

Locality: "Terra Diemenii"

Current status: *Prostomus scutellaris* (F.): Curculionidae, Brachyderinae

Comment: Holotype has been pinned twice, previously through prothorax, now through right elytron. It is in fair condition; both antennae, left prothoracic leg except for coxa and trochanter, tarsi and remaining legs except for right mesothoracic leg, are missing. At one time this species was placed in the genus *Prypnus*. In Junk's Catalogue *C. exsertus* F. is given as a synonym. Fabricius records this species from "nova Cambria", and the type as being in "D. Billardiere".

SEMIPUNCTATUS, Curculio

Fabricius 1775, p. 135, n. 43; 1801, 2, p. 200, n. 11 *(Lixus)*

cyaneipennis Boh. 1859, p. 118 *(Belus)*
lineatus Donov. 1805 *(Brentus)*
var. *poverus* Lea 1917, p. 597 *(Belus)*
Junk's Catal. 1935, 28, 144, p. 11
Zimsen 1964, p. 210, n. 3615

Holotype labels:
i. Fabricius "Curc. semipunctatus Fab. Entom. p. 135, n. 43"
ii. BMNH "Lixus semipunctatus", "Type"

Locality: "nova Hollandia"

Current status: *Belus semipunctatus* (F.): Belidae

Comment: Holotype is in fairly good condition, only right antenna and tarsi of right prothoracic leg are missing. This is a well known species. The number of small whitish tufts of hairs varies tremendously.

SEMIPUNCTATUS, Stenocorus

Fabricius 1775, p. 180, n. 8; 1801, 2, p. 306, n. 8.
inscripta Germar. 1848, p. 226 *(Phoracantha)*
Junk's Catal. 1912, 22, 39, p. 90
Zimsen 1964, p. 172, n. 2901
McKeown 1947, p. 26

Syntype labels:
i. Fabricius "Stenoc. Semipunctatus Fab. Entom. p. 180 n. 8"
ii. BMNH "Stenocorus semipunctatus", "Type"

Locality: "nova Hollandia"

Current status: *Phoracantha semipunctata* (F.): Cerambycidae, Cerambycinae.

Comment: The "type" is in fairly good condition; some joints of both antennae and the left metathoracic leg are missing. There is a second specimen, this is in much the same condition.

The series in the BMNH Collection show that this species varies in size and in the yellow markings on the anterior half of elytra. It has a wide distribution throughout Australia and also been recorded from New Guinea.

SERRATICORNIS, Pyrochroa (Lycus)

Fabricius 1775, p. 203, n. 8; 1801, 2, p. 111 n. 6 *(Lycus)*
Junk's Catal. 1910, 9, 128, p. 73 *(Trichalus)*
Zimsen 1964, p. 134, n. 2155

Holotype labels:
i. Fabricius "Lyc. Serraticornis Fab. Mant. Ins. n. 5"
ii. BMNH "Lycus serraticornis", "Type"

Locality: "nova Hollandia"

Current status: *Trichalus serraticornis* (F.): Lycidae.

Comment: Very little remains of the type and the pieces have been carded. The left antenna is complete, there are seven segments of the right one. The elytra are broken. The legs are missing except for parts of the left pro and mesothoracic legs. The abdomen is detached but still has remains of the wings attached to it. K. G. Blair in 1929 compared this type with the only specimen then in the BMNH, which was from Queensland. The reference given on the label is not the original reference but must have been put on by Fabricius after he had changed its genus but before the publication of Mantissa Insectorum as there is no page number which is p. 164. In this reference he also gives the original genus *Pyrochroa* with the 1781 reference.

SMARAGDULUS, Erotylus

Fabricius 1775, p. 123, n. 6; 1801, 2, p. 13, n. 5 *(Cnodolon)*
cupricollis Hope 1803, omitted from Carter's list
semiticus Pasc. 1869, p. 349 *(Chalcopterus)*
triangularis Haag 1878, p. 104 *(Chalcopterus)*
vigilans Blkb. 1892, p. 432 *(Chalcopterus)*
cairnsi Blkb. 1893, p. 60 *(Chalcopterus)*
Junk's Catal. 1911, 18, 28, p. 578 *(Amarygmus)*
Carter's Check list 1926, p. 162
Zimsen 1964, p. 116, n. 1805

Holotype labels:
i. Fabricius "Erot. smargdulus Fab. Entom. p. 123 n. 6"
ii. BMNH "Cnodulon smaragdulus", "Type"

Locality: "nova Hollandia"

Current status: *Chalcopterus smaragdulus* (F.): Tenebrionidae, Amarygminae.

Comment: The condition of the holotype is fair; the mouth parts are covered in dirt and parts of both antennae, left mesothoracic and both metathoracic legs are missing. As in most species of this genus there is a good deal of colour variation. In this species it varies from a golden coppery metallic colour through various shades of purple to greenish copper, which is the colouring of the holotype.

In Carter's Revision of the Australian Amarygginae (1913: p. 10-11) he noted that *Ch. cupricollis* Hope was a synonym of *Ch. smaragdulus* (F.), the synonym being determined by K. G. Blair (see Carter's reference 1913: p. 11) but omitted it in his check list (1926: p. 162). This is another species which Fabricius re-classified into another genus.

SOLANDRI, Lamia

Fabricius 1775, p. 177, n. 31; 1801, 2, p. 304, n. 126
Junk's Catal. 1922, 23, 73, p. 269 *(Depsages)*

McKeown 1947, p. 160
Zimsen 1964, p. 172, n. 2892

Holotype labels:
i. Fabricius "Lamia Solandri Fabr. Entom. p. 177, n. 31"
ii. BMNH "Lamia Solandri", "Type".

Locality: "nova Hollandia"

Current status: *Depsages solandri* (F.): Cerambycidae, Lamiinae

Comment: The specimen is badly rubbed, most of the pubescence on dorsal surface is absent; terminal joints of right antenna and tarsi of both metathoracic legs are missing. This specimen was named after Dr. C. Solander of the British Museum who went with Banks on the *Endeavour* as another naturalist. Froggatt 1907 p. 199 describes this Cerambycid "as a large beetle clothed with a dense coat of buff hairs". Due to abrasion of the "type" the punctation is distinct. Disc of prothorax is rough and rugose with no distinct tubercles, humeral angle of elytra well marked, striae indistinct but there are large scattered punctures diminishing in size towards the apex.

SPECTABILIS, Curculio

Fabricius 1775, p. 155, n. 144; 1801, 2, p. 537, n. 184
Junk's Catal. 1936, 28, 150, p. 4 *(Chrysolopus)*
Zimsen 1964, p. 219, n. 3796

Syntype labels:
i. Fabricius "Curc. spectabilis Fab. Entom. p. 155, 144".
ii. BMNH "Curculio spectabilis", "Type"

Locality: "nova Hollandia"

Current status: *Chrysolopus spectabilis* (F.): Curculionidae, Aterpinae.

Comments: The condition of the "type" is fairly good though most of the tarsi are missing. In a second specimen all structures are complete . It is probable that the type locality may be Botany Bay as it is a common species in that region and it is where Cook made his first landing in Australia. The genus *Chrysolopus* was put in the sub-family Cleoninae by E. Csiki in Junk's Catalogue 1931, 28, 134, p. 3. In 1936 S. S. Schenkling and G. A. K. Marshall transferred it to the sub-family Aterpinae, see Junk's Catalogue (idem.) with a foot note that before, it had been "incorrectly placed in the sub-family Cleoninae and is now put in its correct position".

STOLATA, Cetonia

Fabricius 1775, p. 50. n. 33 *(Cetonia fasciata);* 1781, p. 58, n. 45; 1801, 2, p. 153, n. 89
fasciata F. 1775, p. 50
perversa Schaum 1844, p. 371 *(Glycyphana)*
brunnipes Kirby 1818, p. 454-478 *(Glycyphana).*
Junk's Catal. 1921, 21, 72, p. 271 *(Glycyphana)*
Zimsen 1964, p. 142, n. 2312
Bacchus 1974, pp. 113 and 122. *(Glycyphana)*

Holotype labels:
i. Fabricius "Stolata Ins. n. 45"
ii. BMNH "Cetonia stolata", "Type"

Locality: "nova Hollandia"

Current status: *Glycyphana stolata* (F.): Scarabaeidae, Cetoninae.

Comment: The Fabrician label has been mutilated and only part of it is left. The condition of the holotype is good and all structures are complete, but its colour has faded. Fabricius changed the name of this species from *fasciata* in the 1775 publication to *stolata* in 1781 because the name *fasciata* was preoccupied (Master's 1932: p. 87). The full reference on the label should be Spec. Ins. p. 58 n. 45. In this reference Fabricius also gives the original 1775 reference with the name *C. fasciata.* M. E. Bacchus (idem.) gives a full discussion and explains the confusion that has arisen in recognising this species and its synonyms.

STREPIDUS F., Rhynchaenus

see *STUPIDUS F., Curculio*

R. strepidus F. is a synonym of *C. stupidus* F.

STRIOLA, Coccinella

Fabricius 1775, p. 79, n. 5; 1801, 1, p. 359, n. 17; 1803, Index p. 32
lineola F. 1775, p. 79
Junk's Catal. 1931-32, 16, 120, p. 309 *(Verania)*
Zimsen, 1964, p. 83, n. 1179

Holotype labels:
i. Fabricius "Cocc. Lineola Fab. Entom. p. 79, n. 5"
ii. BMNH "Coccinella lineola"

Locality: "nova Hollandia"

Current status: *Verania striola* (F.): Coccinellidae

Comment: The condition of the holotype is only fair. There is a large amount of glue present on both dorsal and ventral surfaces, both antennae and left elytron are missing. The pro and mesothoracic legs are covered in dirt and the methathoracic legs are immersed in glue. There has been some confusion in the past over the name of this species. In Gemminger et Harold catalogue it appears as *Alesia lineola* (F.). Mulsant (1866: p. 17) described it under the specific name *striola,* given by Fabricius in the Index 1803 and used by Schonherr (1808: p. 156), who put it in his new genus *Verania.* Korschefsky

lists it in Junk's Catalogue under this genus. Mulsant recognised the Fabrician name *Cocc. lineola* F. as the type name but used the name *V. striola*. In his book (1850: p. 367) he gives no reason for this but just followed Schonherr's nomenclature. Both Zimsen and Korschefsky give *Cocc. striola* F. as a synonym of *Cocc. lineola* F. Zimsen records a second type for *Cocc. lineola* F. The two references are:—

1. No. 1179 "*Cocc. lineola* F. in nova Hollandia, Mus. Dom. Banks., synonym *Coccinella striola* Index Alphabeticus 1803, p. 32".
2. No. 1235 "*Cocc. lineola* Ent. Syst. 1, p. 283, 77" in Americae meridionalis Insulis dom. Smidt, Syst. El. p. 373.96". The type is in Copenhagen where there are seven specimens. This species is now placed in the genus *Psyllobora*.

Sometimes Fabricius named two species in the same genus with the same name, then realising his error he changed the specific name of one. In this case he changed the specific name *lineola* to *striola* for his later publications. Now even though the two species named *lineola* are placed in different genera, according to the International Code the valid name for this species is *striola*.

STUPIDUS, Curculio

Fabricius 1775, p. 139, n. 65; 1801, 2, p. 473, n. 172 *(Rhynchaenus strepidus)*
strepidus F. 1801, p. 473
ingrata Faust 1892, p. 182 *(Tentegia)* new synonym
Zimsen 1964, p. 206, n. 3529

Holotype labels:
i. Fabricius "Curc. stupidus Fab. Entom. p. 139 n. 65"
ii. BMNH "Rhynchaenus strepidus"

Locality: "nova Hollandia"

Current status: *Tentegia stupida* (F.): Curculionidae, Cryrtorrhynchinae.

Comment: Holotype is in good condition, all structures complete though terminal joints of right antenna are hidden beneath rostrum. It is pinned through left elytron.

The name of this species has been omitted from recent catalogues. The type of *T. ingrata* Faust. is at Dresden. There are two specimens in the BMNH identified by Lea as *T. ingrata* Faust. G. J. Arrow in 1929 verified for me that *T. ingrata* Faust. is a synonym of *T. stupida* F. This is another species for which Fabricius changed the name in his later publications, using the name *R. strepidus* in Syst. El. 1801. It is possible that this was merely a spelling error in copying down from one list to another. Therefore the synonyms of *T. stupida* (F.) are *Rhynchaenus* strepidus F. and *T. ingrata* Faust. The BMNH label *R. strepidus* would have been added when the collection was arranged in the order given in Systema Eleutheratorum.

SULCATUM, Callidium

Fabricius 1775, p. 189, n. 11; 1801, 2, p. 340 n. 41
acutipennis White 1846, p. 20 *(Coptomma)*
Junk's Catal. 1912, 22, 39, p. 489 *(Navomorpha)*
Zimsen 1964, p. 179, n. 3037

Syntype labels:
i. Fabricius "Callid. sulcatum Fab. Entom. p. 189 n. 11"
ii. BMNH "Callidium sulcatum", "Type".

Locality: "nova Zelandia"

Current status: *Navomorpha sulcata* (F.): Cerambycidae, Cerambycinae.

Comment: There are two specimens, a male and female. The "type" label is on the male, which is dirty, pinned through left elytron and left metathoracic leg is missing. The female has several parts missing—Both antennae, left prothoracic, right meso and metathoracic legs; left mesothoracic leg is complete but is detached. The male specimen is just over half the length of the female. Broun (1880: p. 590) describes this species fully.

SUTURALIS, Melolontha

Fabricius 1775, p. 34, n. 2; 1801, 2, p. 166, n. 31
chlorophylla Boisd. 1835, p. 188 *(Micronyx)*
prasina Cast. 1840, p. 143 *(Paranonca)*
Junk's Catal. 1912, 20, 47, p. 89 *(Chlorochiton)*
Zimsen 1964, p. 145, n. 2361

Holotype labels:
i. Fabricius "Melolontha Suturalis Fabr. Sp. Ins. no. 15"
ii. BMNH "Melolontha suturalis", "Type"

Locality: "nova Zelandia"

Current status: *Chlorochiton suturalis* (F.): Scarabaeidae, Melolonthinae.

Comment: The condition of the holotype is fair; except for the left antenna (only 2 basal joints present), and the tarsi of all legs are missing, one set of tarsi are lying in the dried glue.

Broun (1880: p. 261) describes this species and Arrow (1903: p. 305) gives the characters of the genus *Chlorochiton* and its relation to nearby related genera.

SYLVICOLA, Melolontha

Fabricius 1775, p. 39, n. 34; 1801, 2, p. 181, n. 123
convexus Boisd. 1835, pl 209 *(Liparetrus)*
salebrocus Macl. ♀ 1886, p. 27 *(Liparetrus)*

macleayi Blkb. ♂ 1888, p. 27 *(Liparetrus)*
Junk's Catal. 1912, 20, 47, p. 98 *(Liparetrus)*
Zimsen 1964, p. 148, n. 2445

Syntype labels:
i. Fabricius "Melolontha sylvicola Fab. Sp. Ins. n. 57"
ii. BMNH "Melolontha sylvicola", "type"

Locality: "nova Hollandia"

Current status: *Liparetrus sylvicolus* (F.): Scarabaeidae, Melolonthinae.

Comment: The condition of the holotype is poor; it is pinned through the left elytron; ventral surface is covered with a thick felt of dried mycelial hyphae and glue; left mesothoracic and both metathoracic legs are missing. Fabricius must have re-examined this species before publishing in 1781 and put the later reference on the label.

Blackburn (1905: p. 311) in his revision of the Australian species of *Liparetrus* gives the following synonyms for *L. sylvicolus* (F):—*L. salebrocus* Macl. ♀, *L. basalis* Blanch. ♂ and *L. macleayi* Blkb. ♂. Burmeister (1855: p. 198) describes both the male and female *L. sylvicolus* (F.)— He says, "nigro pilosus, pronoto canaliculato, pygidio rugoso variloso carinato"—black, hairy, pronotum grooved, pygidium rough and variously ridged. Fabricius's description states, "Caput et thorax glabra, nigra, immaculata"—head and thorax glabrous, black and unmarked. From Blanchard's description (1850: p. 105) of *L. basilis* and that of Burmeister's of *L. sylvicolus* (F.) they could be the same species. In the BMNH there are eleven specimens labelled *L. basalis* Blanch., the habitat labels are from Tasmania, South Australia and Nova Hollandia. In 1929 G. J. Arrow compared these specimens with Blanchard's and Burmeister's descriptions and agreed with me that they were all *L. basalis* Blanch. Burmeister's descriptions were made from specimens sent to him by Hope. He had both sexes and they are not *L. sylvicolus* (F.), but are probably *L. basalis* Blanch., which is now regarded as a distinct species. In Junk's Catalogue 1912 it is listed as a synonym of *L. sylvicolus* (F.). Blackburn never saw the Fabrician type and was evidently misled by Burmeister's description of the specimen he obtained from Hope, as Burmeister stated that he had examined the Fabrician types of the Melolonthinae in London. Blackburn assumed he would have studied and described the type of *L. sylvicolus* (F.), although in his description Burmeister states that he obtained the specimens from Hope. Blackburn did note that Burmeister's description did not coincide with Fabricius's description as regards sculpture and pubescence, but was so sure that Burmeister's description was of the Fabrician type that he concluded that Burmeister's specimens were of the same of species. Fabricius had more than one specimen, there is one in his own collection in Copenhagen, as he adds to his description, "variat interdum elytris fuscus"—at times there is a variation in the elytra which may be dark to tawny.—The type, he describes as "elytra abdomine breviora, laevia nigra"—elytra shorter than abdomen, smooth, black—He also states that the type was in the Banks Collection, but it is possible that he kept the "type" specimen in his own collection and returned another specimen, a variety, to Banks. The specimen, in the Banks Collection has reddish or fuscus elytra, therefore these two specimens should both be regarded as syntypes.

L. basalis Blanch is not a synonym of *L. sylvicolus* (F.) but is a separate species. N. B. In Junk's Catalogue the species is spelt *silvicola*.

TOMENTOSA, Lagria

Fabricius 1775, p. 125, n. 9; 1801, 2, p. 70, n. 9
pulchrivaria Lea. ♀1917, p. 175
Junk's Catal. 1910, 17, 2, p. 13
Zimsen 1964, p. 128, n. 2037

Holotype labels:
i. Fabricius "Lagria tomentosa Fab. Entom. p. 125, n. 9"
ii. BMNH "Lagria tomentosa", "Type"

Locality: "nova Hollandia"

Current status: *Lagria s.g. Ecnolagria* (Borch. 1936 p. 142) *tomentosa* F.: Lagriidae.

Comment: The condition of the holotype is poor, pinned at the sutural margin of left elytron and cracking it; ventral surface distorted; mouth parts covered in dirt; both antennae, terminal tarsus of left prothoracic leg, right prothoracic leg, both mesothoracic legs and tarsi of both metathoracic legs are missing. Lea (1917: p. 175) described the male under the name *L. pulcharivaria*. Blair (1920: p. 155) determined this synonymy. Champion (1895: p. 229) pointed out that the species commonly known as *L. tomentosa* F. from Western Australia does not agree with the Fabricius type, it should be known as *E. aeneoviolacea* Champ. In Masters Catalogue 1885, p. 387 the locality is erroneously given for the Fabrician species as Western Australia.

TRIBULUS, Curculio

Fabricius 1775, p. 153, n. 138; 1801, 2, p. 536, n. 174
?echidna Macleay 1863-66, p. 280
Junk's Catal. 1931, 28, 114, p. 23 *(Leptops)*
Zimsen 1964, p. 219, n. 3786

Holotype labels:
i. Fabricius "Curc. Tribulus Fab. Entom. p. 153, n. 138"
ii. BMNH "Curculio tribulus", "Type"

Locality: "nova Hollandia"

Current status: *Leptopius* (Oke 1951) *tribulus* (F.): Curculionidae, Leptopiinae.

Comment: Holotype is in good condition, only tarsi of prothoracic legs are missing. There has been confusion about the identity of this species. G. A. K. Marshall (1952: p. 265) compared the types of *L. tribulus* (F.) and *L. ferus* (Pasc.), both of which are in the BMNH and stated that they are separate species. What A. M. Lea (1906 p. 326) describes as *L. ferus* (Pasc.), agrees with the Fabrician type of *L. tribulus*. Lea in his table, states that *L. ferus* (Pasc.) has "a rostrum carinate in the middle" which applies to *L. tribulus* (F.) not to *L. ferus* (Pasc.) which is grooved. The description given by Lea of *L. tribulus* (F.) describes that of *L. duponti* (Boisd.). *L. duponti* Boisd. is the common species often erroneously called *L. tribulus* (F.), and mentioned as such in R. J. Tillyard's book of Insects (1926: p. 242). There is a large series in the BMNH labelled *L. duponti* (Boisd.) from Australia. Two specimens in this series have been identified by Lea as *L. tribulus* (F.) but are definitely *L. duponti* (Boisd.). *L. duponti* (Boisd.) (1835: p. 333) is given as a female synonym of *L. tribulus* (F.) in the Gemminger et Harold catalogue. It is not a matter of sexual differences, it is a distinct species.

Therefore, *L. duponti* (Boisd.), *L. tribulus* (F.), and *L. ferus* (Pasc.) are distinct species. *L. echidna* (Boisd.) is given as a synonym in Dejean's Catalogue and Junk's Catalogue and is incorrectly attributed to Macleay. The specimen in the BMNH labelled *L. echidna* (Macleay) (Boisd.) is the same as *L. duponti* (Boisd.) not *L. tribulus* (F.).

TRIDENS, Curculio

Fabricius 1787, 1, p. 122, n. 271; 1801, 2, p. 537, n. 186
sextuberculatus White 1846, p. 13 *(Rhinaria)*
Junk's Catal. 1935, 28, 144, p. 2 *(Agathinus)*
Zimsen 1964, p. 219, n. 2798
Kuschel 1970, p. 197

Holotype labels:
i. Fabricius "Curc. Tridens Fabr. Mant. Ins. n. 271"
ii. BMNH "Curculio tridens", "Type" There is another label but it is unintelligible. It may read "variety sexual of *C. exporti*—Mus Dom Labrielle"

Locality: "nova Zelandia"

Current status: *Agathinus tridens* (F.): Belidae.

Comments: Holotype is a female. Synonym *sextuberculatus* White is a male (Kuschel idem.) Holotype has been pinned twice, now through left elytron, previously through prothrorax; most of the antennae, and all tarsi except those of the left mesothoracic and right metathoracic legs are missing.

TRISTIS, Necydalis

Fabricius 1787, 1, p. 170, n. 5; 1801, 2, p. 370, n. 13
miranda Newm. 1851 App., p. 133 *(Dohrnia)*
anthina Olliff 1887, p. 154 *(Ithaca)*
Zimsen 1964, p. 185, n. 3148

Holotype labels:
i. Fabricius "Necy. Tristis Fabr. Mant. Ins. n. 5"
ii. BMNH "Necydalis tristis", "Type"

Locality: "terra Diemenii"

Current status: *Dohrnia tristis* (F): Oedemeridae.

Comment: Only the abdomen of the holotype remains. This species has been omitted by Schenkling in Junk's Catalogue 1915, 17, 65, p. 72 and the two synonyms are listed as separate species. Blair (1929: p. 158) determined the above synonymy but it has been overlooked by subsequent workers of the species. Blair states, "Unfortunately all that remains of the type is the abdomen attached to the pin. The description in conjunction with Olivier's figure, leaves no doubt that the insect was the female of the species better known as *Dohrnia miranda* Newm., and an examination of the abdomen makes this identity certain. Olliff evidently did not know Newman's insect, but his description is so full and detailed as to leave the synonymy beyond question." This reference is omitted from Musgrave's Bibliography of Australian Entomology. Also R. J. Tillyard used the name *D. miranda* Newm. in his book "Insects of Australia and New Zealand" on p. 225.

TRUNCATUS, Scarabaeus

Fabricius 1775, p. 6, n. 12; 1801, 1, p. 7, n. 18 *(Geotrupes)*
Junk's Catal. 1937, 21, 156, p. 58 *(Pericoptus)*
Zimsen 1964, p. 21, n. 12.

Holotype labels:
i. Fabricius "Scarabaeus Fabr. Sp. Ins. No. 16"
ii. BMNH "Geotrupes truncatus"

Locality: "nova Zelandia" as recorded in 1775 publication.

Current status: *Pericoptus truncatus* (F.): Scarabaeidae, Dynastinae.

Comment: The condition of the holotype is good, only the club of the left antenna and the tarsi of the metathoracic legs are missing. The reference on the label indicates that Fabricius re-examined this specimen in 1780 and put the 1781 reference on the

label. At the same time he must have recorded the locality erroneously as "nova Hollandia" which was copied in his later publications.

TUBERCULATA, Cicindela F.

Fabricius 1775, p. 225, n. 7; 1801, 1, p. 238, n. 32.
tuberculosa Ol. 1790, p. 732
latecincta White 1846, p. 1.
Junk's Catal. 1926, 1, 86, p. 200.
Zimsen 1964, p. 64, n. 800.

Holotype labels:
i. Fabricius "Cicindela tuberculata Fab. Entom. p. 225 n. 7"
ii. BMNH "Cicindela tuberculata"

Locality: "nova Zelandia"

Current status: *Cicindela tuberculata* F.: Cicindelidae.

Comment: The condition of the holotype is fair. It is pinned through the left elytron. Only the three basal joints of the antennae are present, the right mesothoracic leg is entirely missing and none of the others are complete.

There is a second specimen labelled "nova Zelandia, Nel.". This specimen is without head, pro and mesothorax. "Nel." would stand for Nelson, the collector who sailed with Cook on his third voyage. This specimen would, therefore, have been collected at a later date than the holotype.

E. Zimsen records that 2 specimens are in the Banks Collection and one at Kiel but incorrectly records the locality as "nova Hollandia". In both the 1775 and 1801 references Fabricius records the locality as "nova Zelandia". It is a New Zealand species.

UNIFASCIATA, Crioceris (Lema)

Fabricius 1775, p. 120, n. 13; 1801, 1, p. 476, n. 28 *(Lema)*
Junk's Catal. 1924, 24, 51, p. 82 *(Lema)*
Zimsen 1964, p. 107, n. 1644

Holotype labels:
i. Fabricius "Crioc. Unifasciata Fab. Entom. p. 120 n. 13.
ii. BMNH "Lema unifasciata", "Type".

Locality: "nova Hollandia"

Current status: *Lema unifasciata* F. Chrysomelidae, Criocerinae.

Comment: Holotype is pinned through left elytron; left antenna, and terminal segment of right antenna are missing. Femora and tibia of left mesothoracic leg and both metathoracic legs are entangled in the glue. Fabricius re-classified this species into the genus *Lema* in 1801.

VARIEGATA, Leptura

Fabricius 1775, p. 199, n. 19; 1801, 2, p. 375, n. 2 *(Molorchus)*
Junk's Catal. 1912, 22, 39, p. 286 *(Hesthesis)*
Zimsen 1964, p. 186, n. 3163

Type specimen has been lost from the Collection

Locality: "nova Hollandia"

Current status: *Hesthesis variegata* (F.): Cerambycidae, Cerambycinae.

Comment: There is a large series in the BMNH General Collection. McKeown (1947: p. 89) gives a complete list of references but he erroneously records the type as being in the BMNH. This specimen was re-classified by Fabricius in 1801 into the genus *Molorchus*.

VARIEGATUM, Callidium

Fabricius 1775, p. 189, n. 9; 1801, 2, p. 340, n. 39
viratum Newm. 1841, p. 18 *(Coptomma)*
Junk's Catal. 1912, 22, 39, p. 488 *(Coptomma)*
Zimsen 1964, p. 179, n. 3035

Syntype labels:
i. Fabricius "Callid variegatum Fab. Entom. p. 189. n. 9"
ii. BMNH "Callidium variegatum", "Type"

Locality: "nova Zelandia"

Current status: *Coptomma variegata* (F.): Cerambycidae, Cerambycinae.

Comment: There are two specimens a male and female. The male specimen has the Museum "type" label. It is pinned through the left elytron; neither antenna is complete and the legs are entangled in glue on the ventral surface. The condition of the female is in an excellent state of preservation and all structures are complete. Broun (1880: p. 589) gives a detailed description of this species.

VILLOSA F., Saperda

see *HIRTA F. Saperda*

S. villosa F. is a synonym of *S. hirta* F.

VIOLACEUS, Notoxus

Fabricius 1787, 1, p. 127, n. 1; 1801, 1, p. 287, n. 2
niger Sharp 1877, p. 7 *(Balcus)* new synonym
Junk's Catal. Suppl. 1950, p. 297 *(Phymatophaea)*
Zimsen 1964, p. 72, n. 966

Holotype labels:
i. Fabricius "Notoxus violaceus Fabr. Mant. Ins. n. 2"
ii. BMNH "Notoxus voilaceus"

Locality: "nova Zelandia"

Current status: *Phymatophora violaceus* (F.): Cleridae

Comment: Ventral surface is covered with dirt and all legs are closely intertwined. The type of *Balcus niger* Sharp is in the BMNH. A comparison of this type with *N. violaceus* F. shows them to be synonymous. This is a new synonym and was confirmed by K. G. Blair when I was working in the BMNH in 1929. A study of the series of this species in the BMNH shows that this species varies considerably in size, colour and markings on the elytra, which may be three pale spots, two, one or none at all. The Fabrician type has a metallic violet tinge and three pale sports on the elytra; tibiae, tarsi and base of the femorae are ferruginous. The type of *B. niger* Sharp is black and there are no colour spots on elytra; tibiae and tarsi are black. The Fabrician type is devoid of hairs, probably due to abrasion, while the Sharp type is scantily covered with hairs.

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SARCOPTIFORMES (ACARI) OF SOUTH AUSTRALIAN SOILS.

1. NOTATION. 2. BIFEMORATA and PTYCTIMA (CRYPTOSTIGMATA)

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ABSTRACT

LEE, D. C. 1980. Sarcoptiformes (Acari) of South Australian soils. 1. Notation. 2. Bifemorata and Ptyctima (Cryptostigmata). *Rec. S. Aust. Mus.* 18(9): 199-222.

A study of sarcoptiform mites from surface soil (usually greatest depth = 4 cm) at 9 florally diverse sites in South Australia is introduced. A modified notation for mite morphology is presented. The following 6 species of Bifemorata or Ptyctima were collected and are either newly described or annotations are given: *Stomacarus abresi* n.sp., *Loftacarus siefi* n.gn., n.sp., *Ctenacarus araneola* Grandjean, *Protoplophora palpalis* Berlese, *Hoplophthiracarus shealsi* n.sp. and *Rhysotritia wallworki* n.sp.. Some relevant higher taxa are redefined. New synonyms are Aphelacaridae under Adelphacaridae, Ctenacaridae under Palaeacaridae and *Andacarus* under *Stomacarus*. New combinations are *campbellensis, ligamentifer* and *watsoni* (ex *Andacarus*) with *Stomacarus, longicaudatus* (ex *Stomacarus*) with *Loftacarus* and *africanus* (ex *Ctenacarus*) with *Beklemishevia*.

INTRODUCTION

The aim of this study is to give a broad (yet, because of resources, necessarily superficial) indication of the sarcoptiform mite (Cryptostigmata and Astigmata) fauna of South Australian soils. This group was selected because it is startlingly poorly known in Australia and because its members, with two small groups of mites (Notostigmata and Endeostigmata), are the only arachnids capable of ingesting solid particles.

The limited extent of knowledge about Australian Cryptostigmata is illustrated by comparing the known mite fauna of Australia and that listed from New Zealand by Spain and Luxton (1971). Of the 832 species of New Zealand mites, 380 species are Cryptostigmata. Whilst, of approximately 1 300 species of Australian mites, 19 species are Cryptostigmata. This situation will be partially rectified by a study of Cryptostigmata of the Pacific area by Professor Janos Balogh and Dr. Sandor Mahunka of Hungary. It is to be published in the near future, and refers to 200 or more species from Australia, mainly from east coast forest regions (personal communication). As elsewhere, the Astigmata of Australian soils are neither as abundant nor as diverse as the Cryptostigmata. In fact the only abundant species found in this study, and then only at the pasture site, was the cosmopolitan *Tyrophagus similis* Volgin.

The Cryptostigmata and Astigmata in soils feed on decomposing plant material, fungi, algae, bacteria and frass. Solid particles are fragmented and ingested, and are evident as relatively opaque boli in cleared specimens. Unlike purely liquid-ingesting mites they deposit faecal pellets similar to the frass of some insects and containing living micro-organisms. In other words, this group mechanically breaks down plant material, metabolize some of it, and feeds on and disperses organisms that also metabolize it. Furthermore, it is likely that the food preferences of particular species are limited, some, for example, feeding on only fungi, or even only certain fungal species. Therefore a study of variations in their fauna between different sites is pertinent to assessing variations in the decomposing processes that lead to nutrients being made available to growing plants.

During the sorting of samples nearly 30 000 adult Cryptostigmata and Astigmata were separated out and grouped in about 120 species. Relatively few immatures were collected and these are referred to only when they can both be identified and belong to a species that would not otherwise be represented from a particular site.

The author intends to classify the species in a number of publications and then comment on their distribution.

The higher classification used will be defended only as it deviates from that in "The oribatid genera of the world" by Balogh (1972). Since Balogh's classification, although comprehensive, does not answer the plea by Woolley (1971) for improvement in the ill-defined and complex system of classification for the Cryptostigmata, definitions of higher taxa will be presented and there will be a bias towards simplification by reducing the number of superfamilies and families.

All material is deposited in the South Australian Museum, Adelaide.

This particular publication presents the notation used for mite morphology and collection data. Then the six species of mites collected that belong to the Bifemorata and Ptyctima are classified and described when necessary.

NOTATION FOR MORPHOLOGY

Unless specified, attributes belong to adults. Much of the description of the soma is dealt with under four headings related to the areas illustrated (Fig. 1). The term *external mala* (see Hughes 1959: 139) is used rather than 'rutellum', and *spermapositor* rather than 'penis' since the relevant structure is not an intromittant organ. The term *cowl* is used for a proteronotal rostral hood which encompasses the retracted gnathosomal appendages, a condition previously referred to as 'stegasimy'. A partly new notation for hairs, chaetotaxy and pores is presented below, plus that for mensuration.

Hairs

Hairs are regarded either as *setae* if they have actinochitin and are hollow with no protoplasmic core, *solenidia* if they have no actinochitin and a protoplasmic core, *plasmic setae* ('eupathidia', 'famuli' and 'sensilli') if they have both actinochitin and a protoplasmic core. All hairs examined in this study exhibited only peripheral birefringence under polarized light, so they apparently always lack an actinochitin core. Solenidia usually occur dorsally on the distal segments of appendages, and are all referred to by the symbol *so*, and numbered, the more proximal and anterior solenidia first.

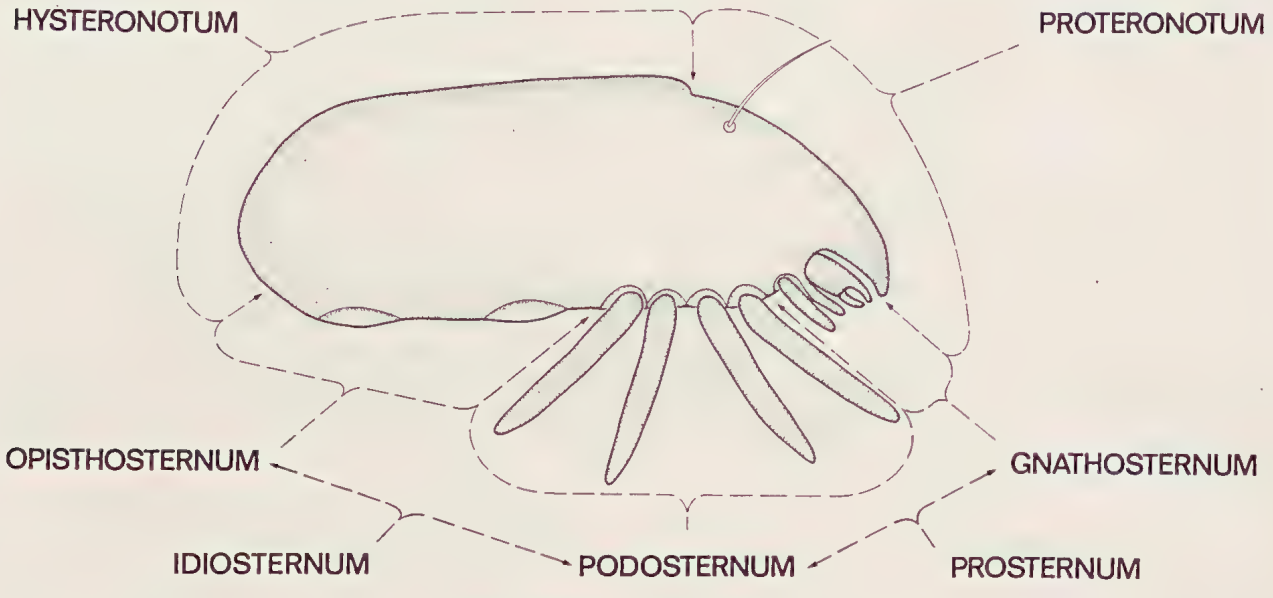


Fig. 1—Zones of soma surface.

Chaetotaxy of Soma

Up to four systems of notation for dorsal setae of Cryptostigmata have been used in a single publication, and a fifth system is usually used for the Astigmata. This has sprung from a desire to link the systems of notation with only confident proposals of homology. On the other hand, confusion results from multiple systems, and this has led me to follow a single system with less stringent proposals of homology. This system was initially applied to the opisthonotal shield of species of *Zercon* by Sellnick (1944) and then modified and extended to the notum of other members of the Gamasina (Mesostigmata) by Hirschmann (1957) and Lindquist and Evans (1965). Amongst sarcoptiform mites it has been used only for the Pelopoidea (Cryptostigmata) by Schweizer (1956) and Hammer (1972). It is based on a grid in which the ranks are represented by numbers and the files by letters derived from German words (*J*, inner = central; *Z*, zwischen = between; *S*, seiten = lateral; *R*, rand = edge). Capitals are used for hysteronotal files and lower case letters for proteronotal files. The complete dorsal chaetotaxy (holotrichous condition) is regarded as three pairs of files with two proteronotal ranks and six hysteronotal ranks. Further setae may be present: if lateral to file *S*, and possibly representing a further file, they are referred to file *R*; if they clearly reflect a hypertrichous condition they are represented by the notation for the file lateral to them combined with 'x' as in *Jx*. When only a few setae are missing compared with the holotrichous condition, the absence of a setal pair is illustrated by a circle and superimposed cross in order to indicate the numbering used in the text. For example, in Fig. 2, the third seta in file *Z* is *Z4* not *Z3*, *Z3* being regarded as missing and represented by a circle and cross. Also on illustrations, a number as a prefix to the file signature, for example as in *5Z*, indicates how many setae are present in the file.

The ventral setae are either strictly somal setae or they are born on coxal regions which merge in with the soma. The opisthosternal setae belong to the former group and have notations similar to those of the hysteronotal setae except that they are regarded as either aggenital or adanal, the *g* or *a* representing one or other group being prefixed by either *J*, *Z* or *S*. The genital setae, those actually on the ovipositor

or spermapositor, are either proximal *(pg)*, median *(mg)* or distal *(dg)* and are numbered from the anterior. The podosternal setae are labelled by a roman numeral representing the leg articulating with their coxosternal zone, sometimes followed by a number representing ranks of which the first is at the adaxial end, and then by either *a* (anterior), *m* (median), *p* (posterior) or *d* (dorsal). The gnathosternal setae are regarded as adoral *(ao)*, postoral *(po)*, palp coxosternal *(c)* and supracoxal (cd). the numbers and letters applied to palp coxosternal setae are as for the podosternal setae.

Chaetotaxy of the Appendages

The widely used notation for the leg setae of sarcoptiform mites is based on french words such as 'unguinale' and 'fastigiale'. It was devised by Grandjean in 1935 and later modified to make the notation for the lateral surfaces of legs I and II match the homologous surfaces of legs III and IV (Grandjean 1940a). Because the system is esoteric and linked to debatable proposals of homology, I have used a system which is a manifest reference to setal position. Although in some instances I have not been able to rigidly keep to this. For example, the proximal dorsal seta, *d*1, on tarsus I ('famulus') has been regarded as occurring in different positions (compare Figs. 7, 27 and 42).

The widespread convention amongst specialists describing characters on arthropod appendages is to refer to their position as if on a cylinder-like segment and to use co-ordinates of two signature systems based on their location both on a hypothetical circular cross-section of the cylinder and on the straight proximal-distal axis. Two such notations have been ignored by acarologists. One was proposed by Newell (1956 and 1957) for *Oppia* (Cryptostigmata) and the other by Southcott (1961) for the Erythraeoidea (Prostigmata). On the other hand, a notation that dramatically improved methods of distinguishing families of Gamasina, proposed by Evans (1963), is now used generally for the Anactinochaeta. The Anactinochaeta is the other of the two major groups of mites. Sarcoptiform mites belong to the Actinochaeta which have optically active chitin in their setae. Amongst the Anactinochaeta a single whorl of setae at a particular position on the proximal-distal axis is considered (Evans 1963) to be basically made up of 6 setae (2 dorsal, 1 anterior, 2 ventral, 1 posterior). Amongst the Actinochaeta a single complete whorl is considered as including 7 setae (1 dorsal, 2 anterior, 2 ventral, 2 posterior) as on tibia I of *Palaeacarus* (see Grandjean 1940b: Fig. 1). On the other hand the 'fastigiale', 'tectale' and 'itérale' setae on tarsus I (see Grandjean, 1954c: Fig. 5A) are apparently 3 pairs of dorsal setae. Therefore, I am regarding a single whorl as including setae that can be referred to one of 8 positions (2 dorsal, 2 anterior, 2 ventral, 2 posterior), although a complete whorl of 8 setae has not be described, and no claim is made here that such a whorl is a lost primitive condition. The notation used for the eight positions is *ad, pd; dp, vp; pv, av; va, da* as illustrated (Fig. 19). In each pair of letters the last one represents the major area. If there is only one seta present in a particular quarter of the circumference then only this last letter is given. Since paired dorsal setae only occur in the absence of paired anterior and paired posterior setae, it is possible that one or both of the paired dorsal setae *(ad, pd)* are homologous with a dorso-anterior *(da)* or a dorso-posterior *(dp)* seta or both on other segments. The apparently dorsal setae on the tarsus, for example, having migrated dorsalwards from a primitive lateral location. The whorls are numbered from the proximal to the distal end, tarsus I is regarded as having 4 whorls, or a maximum potential or 32 setae. Whilst there are usually considerably fewer than 32 setae, members of the Bifemorata may have more, a condition which is regarded here as hypertrichous.

Pores

Balogh (1972) classifies pores into the following groups (notation in parentheses): slit-like pores *(ia, ip, ips, ih)*; reduced sacculi pores *(Pa, P_1, P_2, P_3)*; sacculi *(Sa, S_1, S_2, S_3)*; areae porosae (Aa, A_1, A_2, A_3, *Ad, Al, App)*. Because some of these letters are already in use, I am using *'f'* (foramen) as a signature for all pore types. Slit or punctiform pores are prefixed by *h* (hysteronotal), *Za* (lateral adanal) or *Ja* (central adanal). Sacculi, which are always hysteronotal are prefixed by *s* and similarly area porosae by *m* (multiporose area). A number following the signature equals the rank of a particular pore and a number before indicates how many pores are in the file. The pore of the lateral hysteronotal gland duct is referred to as *hGf*.

Mensuration

Measurements are in microns (μm). The idiosomal length is an average of the number of specimens which are indicated afterwards in parentheses with their range of lengths. For members of the Ptyctima, hysterosomal and proterosomal lengths are given separately. The idiosomal length of the holotype, or about average size specimen for established species, from which the appendage measurements were taken, is given in parentheses before these measurements. Lengths for the chelicera are the longest axis of the movable digit and for the palp and legs are the distances from the base of the trochanter to the tip of the tarsus. The breadths are the greatest width of the femur or, in

the case of the Bifemorata, the telofemur. In the case of the mites longer than 250 μm measurements are to the nearest 5 μm for most lengths and nearest 2·5 μm for the cheliceral length and all breadths. For mites under 250 μm in length the measurements are to the nearest 2·5 μm for most lengths and the nearest 1·0 μm for the cheliceral length and all breadths.

NOTATION FOR DISTRIBUTION DATA

Under the heading of 'Material examined', collection data and registration numbers are given for all mites examined in detail. Under 'Distribution' a wider indication is given of where a species is known to occur using a notation for geographical location, South Australian sites that are part of this study, and numbers of mites and their distribution amongst samples. This notation is explained under three headings: 'samples', 'sites', 'geographical location'. The sampling process and sites will be considered in more detail in the final paper of this series that will be concerned with the distribution of the relevant mites.

Samples

Samples were collected in plastic bags in a manner similar to a method I previously used (Lee 1973). They were, therefore, disturbed and would not have yielded such a high proportion of their mite fauna as undisturbed core samples. The top 4 cms of soil, plant litter, moss and other plants with a similar growth form were collected from 25 × 25 cm squares. An exception to this was the Knott Hill cultivated pine forest site from which, because of the unusual depth of the litter, four samples of different layers to a depth of 16 cms were taken from each 25 × 25 cm square. Usually samples of eight 25 × 25 cm squares were taken from each site, so that the number of adults of a particular species of mite at a site represents an extraction from half of a square metre of soil surface area, but collections from only two 25 × 25 cm squares were taken from the Knott Hill cultivated pine forest site.

The numbers given after the site, for example 10 (5/8), equal the number of adults collected and, in parentheses, the number of 25 × 25 cm squares of soil surface that the adults were taken from as a fraction of the total number sampled (usually 8, but 2 in the case of the pine forest site).

Sites

Sites were selected in order to represent floral diversity using the description of South Australian vegetation by Specht (1972). They also present a wide range of geographical locations. All nine sites are given a brief description below. The mites referred to in this publication were only collected from five of the nine sites, but the value of the negative results is emphasized. No attempt has been made to register seasonal variations in populations. In all instances sampling was done when the ground was relatively damp and therefore the sarcoptiform mite population was presumably relatively large. The sites with the lowest rainfall are listed first for those with native flora, whilst the two final cultivated sites have the one with the highest rainfall listed first. Annual rainfall figures given below are ranges of average annual rainfalls that include such a value for a particular site. Prior to cultivation the flora of the cultivated sites would have been similar to the savannah woodland in the case of pasture and sclerophyll forest in the case of pine forest.

1. Arid tussock grassland: Victoria Desert, 28° 41′ S, 132° 08′ E. Bases of love grass *(Eragrostis eriopda)* tussocks amongst patches of tall mulga *(Acacia aneura)* shrubland, on deep red siliceous sand of swale between ridges. Annual rainfall: 125-150 mm, sporadic. 11.10.1976.
2. Semi-arid low shrubland: Koonamore, 32° 07′ S, 139° 21′ E. Litter, moss and other low growth plants under bladder saltbush *(Atriplex vesicaria)* amongst false sandalwood *(Myoporum platycarpum)* low open-woodland, on rolling plain, with sandy clay loam on limestone pan. Annual rainfall: 150-200 mm, sporadic. 27.4.1974.
3. Mallee-broombush open-scrubland: Ferries-McDonald, 35° 15′ S, 139° 09′ E. Litter and sparse moss, under ridge-fruited mallee *(Eucalyptus incrassata)* clumps amongst broombush shrubs *(Melaleuca uncinata)* on low hill with shallow calcareous sandy soil and sparse clayey subsoil on limestone pan. Annual rainfall: 350-400 mm, mainly winter. 20.6.1974.
4. Mallee-heath tall open-shrubland: Tamboore, 35° 57′ S, 140° 29′ E. Litter under banksia shrubs *(Banksia ornata)* amongst sclerophyllous shrubs and sparse brown stringy bark mallee *(Eucalyptus baxteri)* on ridge in area of deep calcareous sand. Annual rainfall: 450-500 mm, mainly winter. 4.7.1974.
5. Coastal closed-scrubland: Piccaninnie Ponds, 38° 03′ S, 140° 57′ E. Litter and sparse grass under coastal wattle *(Acacia sophorae)* with little light beneath canopy on black calcareous sand at landward edge of coastal dunes, sometimes inundated from permanent pond fed by fast flowing underground streams from limestone hills. Annual rainfall: 700-750 mm, mainly winter. 3.7.1974 and 20.8.1975.
6. Savannah woodland: Chambers Gully, 34° 58′ S, 138° 41′ E. Either litter under manna gum trees *(Eucalyptus viminalis)* or grass and moss in between these trees on shallow red brown loam of gully slopes in Mt. Lofty foothills. Annual rainfall: 900-950 mm, mainly winter. 12.6.1974.
7. Sclerophyll forest: Mt. Lofty, 34° 59′ S, 138° 45′ E. Litter and sparse moss under Sclerophyllous shrubs amongst messmate stringybark *(Eucalyptus obliqua)* in forest near summit of Mt. Lofty on shallow, grey siliceous sand. Annual rainfall: 1150-1200 mm, mainly winter. 9.5.1974.
8. Pine forest: Knott Hill, 35° 12′ S, 138° 41′ E. Litter under cultivated *Pinus pinea* with little light beneath canopy on siliceous sandy soil on rolling hills in Mt. Lofty Ranges. Annual rainfall: 950-1000 mm, mainly winter. 22.5.1974.
9. Pasture: Glenthorne, 35° 02′ S, 138° 32′ E. Bases of cultivated grass and plantain *(Plantago lanceolata)* on deep brown loam on rolling hill in foothills of Mt. Lofty Ranges. Annual rainfall: 500-550 mm, mainly winter. 12.6.1974.

Geographical Location

Geographical regions are represented by 2 or 3 letters, the first of which, in capitals, equal the major

region. They are as follows: Nearctic (Nn—northern, Nc—californian, Nr—rocky mountain, Na—alleghanian); Neotropical (NTm—mexican, NTa—antillean, NTb—brazilian, NTc—chilian); Ethiopian (Ew—west, Ee—east, Es—south, Em—malagasian); Palaearctic (Pe—european, Pm—mediterranean, Ps—siberian, Pc—manchurian); Oriental (Oi—indian, Oc—ceylonese, Os—indochinese, Om—indomalayan); Australian (Am—malayan, Aa—australian, Ap—polynesian, An—newzealandian); subantarctic (Sm—magellanian, Sk—kerguelenian, Sa—antipodean); Antarctic (ACr—rossian, ACs—scotian). For details of divisions between these regions see the map that I have previously published (Lee 1970: p. 207).

SYSTEMATICS

Cohort BIFEMORATA

Diagnosis: Macropylina (Balogh 1972: 31). Pale adult with weakly delineated shields not completely encasing soma. Rostrum never longer than distance between setae *j*1-*j*1 and does not form cowl capable of encompassing retracted gnathosomal appendages. Genital and anal shields together almost as long as opisthosternum, and never separated by more than length of seta *Ja*1. No conspicuous idiosternal division. Coxae distally free from podosternum. Femur divided into basifemur and telofemur. Either tarsus I or tibia I or both with 4 solenidia. Between 20 and 40 setae on tarsus I. Immatures similar to adult.

Remarks: The classification by Balogh (1972) follows that of Grandjean (1969) to include six families grouped in three superfamilies, but the listing of *Beklemishevia* (under Ctenacarinae below) and *Tragardhacarus* (under Palaeacarinae below) under Aphelacaridae is original and probably constitutes a typing error. I have reverted to an earlier classification (Grandjean 1954c) in regarding the three superfamilies as families. But in introducing new characters to delineate these families, I have grouped Ctenacarinae under Palaeacaridae rather than with the Adelphacarinae. There are also less important changes in the classification. Whilst members of the Acaronychidae and Palaeacaridae were collected in the present study and are considered below, no adelphacarids were collected so they are briefly considered here. Adelphacaridae (Adelphacarinae Grandjean, 1954c: 198) includes two genera: *Adelphacarus* Grandjean, 1952b (not 1932 as given by Balogh, 1972) and *Aphelacarus* Grandjean, 1932b. It is known from the Nearctic and Palaearctic Regions. Aphelacaridae Grandjean, 1954c is newly synonymous with Adelphacaridae and is regarded as junior since it is listed after it on the same page, despite the fact that its type genus is much better known and for a longer time. *Adelphacarus* is based on a single specimen from Sweden with the region of the first rank of hysteronotal setae destroyed. Grandjean (1954c) distinguished Aphelacaridae by its having only two pairs of genital papillae and deep furrows rather than fine striations behind the proteronotal shield, which is not considered adequate here to distinguish a suprageneric taxon.

Key to Families of Bifemorata (Adult)

1. Aggenital file *Jg* includes 6 setae. If proteronotal shield present, it is not extensive enough anteriorly to carry either setae *j*1 or *z*1. Some hysteronotal setae conspicuously stouter than others. Seta *Z*2 shorter than *J*3 (0·75 × or less) and approximately level with *J*2 (*Z*1-*Z*2: *J*1-*J*2 = 0·9 or more:1) ..... Acaronychidae
   Aggenital file *Jg* includes 7 setae. Proteronotal shield present and carrying setae *j*1 and *z*1. If some hysteronotal setae conspicuously stouter then seta *Z*2 is longer and conspicuously displaced forward..... 2
2. Aggenital seta *Jg*1 hammer-like or claw-like. Some hysteronotal setae conspicuously stouter than others. Seta *Z*2 is subequal to or longer than *J*3 and conspicuously displaced forward (*Z*1-*Z*2:*J*1-*J*2 = 0·25-0·5:1) .... Palaeacaridae
   Aggenital seta *Jg*1 setose. Hysteronotal setae all relatively slim. Seta *Z*2 shorter than *J*3 (0·6 × or less) and moderately displaced forward (*Z*1-*Z*2:*J*1-*J*2 = 0·6-0·75:1) ..... Adelphacaridae

Family ACARONYCHIDAE Grandjean

Acaronychidae Grandjean, 1932b: 426.
Archeonothridae Grandjean, 1954a: 428.

Type genus: *Acaronychus* Grandjean, 1932b.

Diagnosis: Bifemorata. Gnathosternal seta *ao*1 simple or bifid. Proteronotal shield absent or limited to posterior half of proteronotum. Rostrum has ventral recess with bilobed refractile lining (equals "oeil" of Grandjean, 1958b). Some hysteronotal setae conspicuously stouter than others, with seta *Z*2 shorter (0·75 × or less) than *J*3 and approximately level with *J*2 (distance ratio *Z*1-*Z*2:*J*1-*J*2 = 0·9 or more:1). Aggenital file *Jg* with six setose setae. On tarsus I seta *d*1 proximad to solenidium *so*1, subequal in length or longer than *so*1, and ciliate. Tibia II with 2 solenidia. Pretarsi with 3 claws, central claw less than quarter the length of lateral claws.

Remarks: Acaronychidae is used here as by Sheals (1965) and is equivalent to Archeonothroidea Grandjean, 1969 which is used by Balogh (1972). It is not known why Grandjean treats Archeonothridae as having priority over Acaronychidae or if there is any basis for Balogh (1972) giving it the authority with the apparently incorrect date of 1932. Sheals (1965) compared the genera of this family and considered that it might be preferable to consider them as a single relatively homogeneous group. I am currently retaining two subfamilies but including a new grouping of genera. A study of the four unnamed species from South Africa referred to by Grandjean (1958a: 76) might resolve which grouping

is best. One of these unnamed species was grouped in *Stomacarus* and is commented on below in the remarks on that genus, although it would be grouped in the Archeonothrinae as defined here.

Subfamily ACARONYCHINAE

Acaronychidae Grandjean, 1932b: 426.

Type-genus: *Acaronychus* Grandjean, 1932b.

Diagnosis: Acaronychidae. Female genital setae thickened to stout, curved spines, conspicuously shorter than the aggenital setae. The longest hysteronotal seta *(J3)* shorter than distance between setal bases *J*3 and *z*1. Seta *J*2 marginally posterior to *Z*2. Opisthosternal setal file *Sa* includes 2 setae. On tarsus I, setae *ad*4 and *pd*4 not plasmic, but similar to setae *d*3.

Distribution: Southern temperate and subantarctic regions (see *Stomacarus).* In northern temperate regions represented by *Acaronychus* between latitudes 30° and 50° North, mainly in hilly or mountainous country (Oregon—Nc; North Carolina—Na; France—Pe; Tangiers, Algeria, Caucasus Mountains—Pm; Tadzhik Soviet Socialist Republic—Ps).

Remarks: The modification of the female genital setae is heavily weighted so that *Stomacarus* (assumed synonymous with *Andacarus*) is grouped in this subfamily for the first time. Members of the subfamily also have correlated attributes such as relatively short hysteronotal setae. The following 2 nominal genera are included in the Acaronychinae: *Acaronychus* Grandjean, 1932; *Stomacarus* Grandjean, 1952a.

STOMACARUS Grandjean

Stomacarus Grandjean, 1952a: 360.
Type-species*: Stomacarus tristani* Grandjean, 1952a, by monotypy.
Andacarus Grandjean, 1958a: 81. **n.syn.**
Type-species*: Stomacarus macfarlani* Grandjean, 1957, by monotypy.

Diagnosis: Acaronychinae. Ciliated seta *d1* on tarsus I with only slightly spatulate tip (no wider than distance between tips of nearby cilia). Proteronotal shield conspicuous, with reticulate markings and carrying at least seta *j2*. Setal pairs *J*1 and *Z*1 all on single hysteronotal shield. Delineated tip of mentum broad-based, wider than distance between setal bases *c1p* and *c2*. Lines from setal base *c1a* to *c1p* and *c2* would enclose an acute angle. Opisthosternal setal file *Sg* includes 2 setae.

Distribution: Southern temperate and subantarctic regions between latitudes 25° and 55° South. All records are with the original descriptions of nominal species except for *S. macfarlani* Grandjean, 1957, El Bolsón, Argentina—NTc (Balogh and Csiszár, 1963) and *S. ligamentifer* (Hammer 1967), Tahiti—Ap (Hammer 1972).

Found on ground, with dead leaves and branches, or on mosses, liverworts, low plants and lichens on bark.

Remarks: Only male attributes are known for the type species of *Stomacarus* based on a single specimen from Tristan da Cunha. Grandjean (1958a) examined two females of one amongst the four new species of South African 'Archeonothrinae' before him. They were small, their genital setae on the ovipositor were somewhat enlarged proximally but slim medially and distally as on the male spermapositor of similar species and, finally, their hysteronotal setae were similar to those of *S. tristani.* From these few attributes, and because the fauna of Tristan da Cunha is likely to be similar to that of South Africa, he grouped this unnamed species in *Stomacarus.* This led him to exclude *S. macfarlani* from *Stomacarus* because of its stout curved, genital setae and establish it as the type of *Andacarus.* If Grandjean (1958a) was correct, then according to the classification presented here, *Stomacarus* and *Andacarus* would be in separate subfamilies. Although three of the five characters used in the diagnosis of Acaronychinae are not known for *S. tristani,* the other two do fit, and at least one other mite, *Parasitiphis aurora* Lee, 1970, in a genus with a similar far southern distribution to *Andacarus,* is found in the Tristan da Cunha Island Group. Therefore, I have excluded the unnamed South African *'Stomacarus'* females (Grandjean 1958a) from *Stomacarus* and regarded *Andacarus* as synonymous with *Stomacarus.* If a female of *S. tristani* is found and none of its genital setae are thickened curved spines then the subfamily groupings as presented here will have to be disregarded.

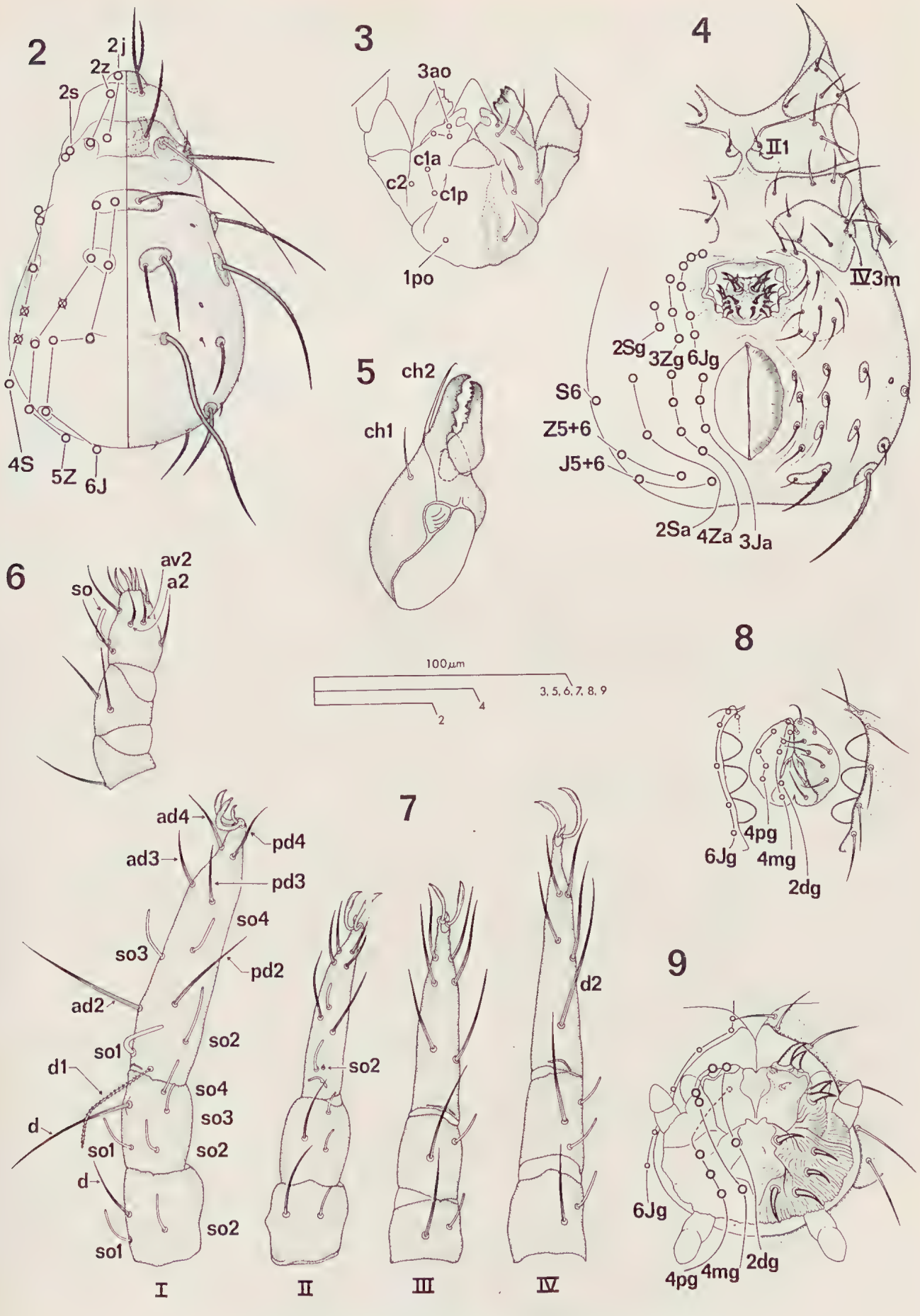
The following 6 nominal species are included in *Stomacarus: S. abresi* **n.sp.,** South Australia—Aa; *S. campbellensis* (Wallwork, 1966) **n.comb.,** Campbell Island—Sa; *S. ligamentifer* (Hammer 1967) **n. comb.,** New Zealand—An; *S. macfarlani* Grandjean, 1957, Argentina—NTc; *S. tristani* Grandjean, 1952a, Tristan da Cunha—Sk; *S. watsoni* (Travé, 1964) **n. comb.,** Macquarie Island—Sa.

Stomacarus abresi n.sp.

Figs. 2-9

Female

General appearance and measurements: Dull ivory-white, with apricot-coloured shields and legs. Extremities of chelicerae and external malae, hysteronotal setae and female genital setae blackish brown. Other setae and claws are light brown.



Figs. 2-9—*Stomacarus abresi* n.sp. 2-7 and 9, female: 2, notum; 3, gnathosternum; 4, idiosternum; 5, left chelicera, anterior surface; 6, part left palp, anterior surface; 7, legs, dorsal setae on genua, tibiae and tarsi; 9, ovipositor, ventral view, partially extruded. 8. male: spermapositor, ventral view.

Idiosomal length 350 (20, 305-370, amongst which those with only one or no eggs are 355 or less); appendage lengths (for 320)—*ch* 40, *pa* 105, *I* 290, *II* 210, *III* 190, *IV* 275; telofemur breadths—*pa* 22.5, *I* 40, *II* 32.5, *III* 30, *IV* 27.5.

Prosternum: Gnathosoma drawn (Fig. 3) is dorsoventrally squashed. Palp coxite seta *cd* shorter but stouter than seta *ao*1 and lying just dorsal to palp. Seta *ao*1 is simple and setose. Whilst extremities of external mala are strongly refractile, those of internal mala are hyaline. Coxosternal seta *Id* shorter but stouter than seta *ao*1 and lying just dorsal to leg I. Coxosternal seta *III*1 set in a notch in the edge of coxite II. On coxite IV there is a median seta *(IV*3*m)* in the distal whorl (unlike *Acaronychus tragardhi).*

Proteronotum: Proteronotum drawn (Fig. 2) foreshortened because it was tipped ventralward. Plasmic seta, *z*2, finer than illustrated. Apodemes extend anteriorad from setal bases *j*2 and *s*2. Proteronotal shield between setae *j*2 has a reticulated pattern of punctations, and extends laterally to encompass base of seta *z*2 and carry setae *s*1 and *s*2.

Opisthosternum: Shields around genital orifice only vaguely delineated. Pore-like structure on ovipositor proximad to seta *dg*1 (possibly equals reduced seta on *Stomacarus macfarlani* Grandjean, 1957).

Hysteronotum: Shields not so clearly delineated as drawn and adaxial setae are foreshortened because of the angle of their axis (Fig. 2). Larger setae with two rows of small cilia.

Appendages: Chelicera with grooved notch on proximal edge of anterolateral surface. Setae: *ch* (2), *pa* (0-2-1-3-18), *I* (0-4-6-5-6-37), *II* (1-5-6-5-7-27), *III* (2-2-3-3-6-26), *IV* (3-3-3-4-5-25). Solenidia: *pa* (0-0-1) *I* (2-4-4), *II* (1-2-3), *III* (1-1-0), *IV* (1-2-0). On tarsus II solenidium *so*2 is very small (regarded as "famulus" by Grandjean, 1957: 217—i.e. seta *d*1).

Eggs: Amongst 20 type females, four have 0 eggs, five have 1 egg, six have 2 eggs, four have 3 eggs, one has 4 eggs. Eggs about 130μm long, ellipsoid with uniform smooth surface.

Male

Measurements and spermapositor (otherwise as female): Idiosomal length 340 (3, 345-360). All genital setae are setose, shorter but of similar diameter to aggenital setae. No equivalent of anterior pore noted.

Material examined: Holotype female (N197613), 19 paratype females (N197614-N197632), allotype male (N197633) and 2 paratype males (N197634 and N197635), moss and litter under *Eucalyptus obliqua*, sclerophyll forest, Mt. Lofty 9.5.1974, D. C. Lee. Undesignated female (N197636) and male (N197645) litter under *Eucalyptus incrassata*, mallee, Ferries-McDonald Reserve, 20.6.1974, D. C. Lee. Undesignated protonymph (N197784), litter under *Pinus pinea*, Knott Hill Forest, 22.5.1974, D. C. Lee.

Distribution: South Australia—Aa: Ferries-McDonald, mallee-broombush open-scrubland, 10 (5/8); Mt. Lofty, sclerophyll forest, 23 (5/8). Knott Hill, cultivated pine forest, 1 protonymph (−/2).

Remarks: In order to distinguish *S. abresi*, species of *Stomacarus* can be regarded as including two groups: those with a slim, tapering proteronotal seta *z*2, and those with a tape-like or lanceolate seta *z*2. The latter group *(S. campbellensis, S. ligamentifer* and *S. watsoni)* from New Zealand and its far southern islands have a narrow, square-shaped proteronotal shield only carrying seta *j*2, also the small hysteronotal seta *J*4 is either on the same shield as *Z*4 or its base is as close to setal base *Z*4 as its length. The former group includes *S. abresi, S. macfarlani* and *S. tristani. S. abresi* can be distinguished from *S. macfarlani,* which has a narrow proteronotal shield and seta *J*4 on the same shield as *Z*4 as in the latter group. *S. abresi* can be easily distinguished from *S. tristani,* which differs from all other known species of *Stomacarus* in having longer, sinuous, smooth hysteronotal setae. On the other hand *S. abresi* and *S. tristani* are similar in having a broader proteronotal shield and seta *J*4 further from seta *Z*4 and not on the same shield. *S. abresi* also differs from both *S. tristani* and *S. macfarlani* in having five setae on basifemur II rather than four setae. *S. abresi* also differs from *S. watsoni,* as well as *Acaronychus tragardhi,* in having a setose rather than a bifid seta *ao*1.

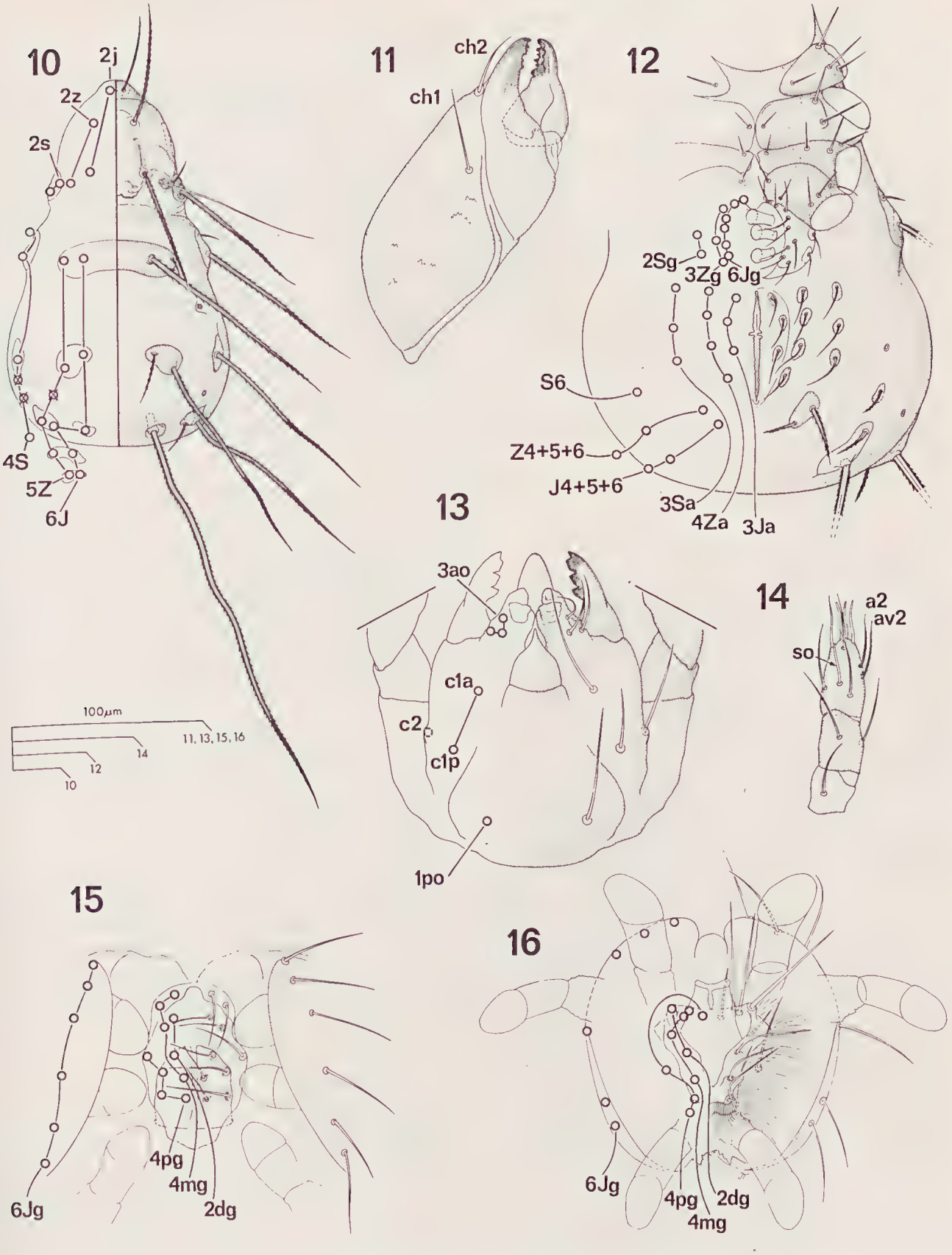
Subfamily ARCHEONOTHRINAE Grandjean

Archeonothridae Grandjean, 1954a: 428.

Type-genus: *Archeonothrus* Trägårdh, 1906: 871.

Diagnosis: Acaronychidae. Female genital setae may be slighty thickened to spines, but, if so, then straight and longer than aggenital setae. The longest hysternonotal seta (*J*3) longer than distance between setal bases *J*3 and *z*1. Seta *J*2 at least marginally anterior to *Z*2. Opisthosternal setal row *Sa* includes 3 setae. On tarsus I, setae *ad*4 and *pd*4 differ from setae *d*3 in being plasmic.

Distribution: Southern temperate regions; South America and South Australia (see *Loftacarus*) and South Africa (*Archeonothrus,* see Grandjean,



Figs. 10-16—*Loftacarus siefi* n.sp. 10-14 and 16, female: 10, notum; 11, left chelicera, anterior surface; 12, idiosternum; 13, gnathosternum; 14, part left palp, dorsal surface; 16, ovipositor, ventral view, partially extruded. 15, male: spermapositor, ventral view.

1958a). In Northern temperate regions represented by *Zachvatkiniella* and *Amuracarus* between 25° and 50° North, and 40° and 150° East, in mountainous country (Caucasus Mountains—Pm; Nepal—Os; far eastern Siberia, east of Lake Baikal and Sichote Alinja—Ps; Japan—Pc).

Remarks: I regard the relative lack of modification of the female genital setae as the most important attribute in diagnosing this subfamily. When the four unnamed species from South Africa referred to by Grandjean (1958a: 76) and probably belonging to this subfamily, are better known they may require changes in both the generic and subfamilial groupings within the Acaronychidae. The following 4 nominal genera are included in the Archeonothrinae: *Amuracarus* Lange, 1975; *Archeonothrus* Trägårdh, 1906; *Loftacarus* **n.gn.**; *Zachvatkinella* Lange, 1954 (=*Himalacarus* Sheals, 1965).

LOFTACARUS n.gen.

Type-species: *Loftacarus siefi* n.sp.

Diagnosis: Archeonothrinae. On coxite IV, 5 setae including seta *IV3m*. Opisthosternum with 2 setae in row *Sg* and 3 setae in row *Sa*. Proteronotal shield absent. Hysteronotal setal pair *J3* not on single shield and bases not connected by thickened strip of cuticle. Setae *J4* and *Z4* on same shield. Seta *Z6* tapering from base and ciliate. Cheliceral fixed digit with 6 or fewer teeth. Seta *v* present on telofemur II and III, and genu III, so that these segments carry 6, 4 and 4 setae respectively. Seta *av* absent from basifemur IV, leaving only 2 setae. Genu I with 2 solenidia. Tarsus II with 2 solenidia of which *so* 2 is very small.

Distribution: Southern temperate regions between 35° and 40° South (probably more extensive than this). All records with original descriptions of nominal species.

Remarks: Loftacarus appears most similar to *Amuracarus* although it can be distinguished from it by the two attributes given below. I have only seen one diagnosis of *Amuracarus* (Lange 1975) which quotes the authority of this name as "Lange, 1975" but does not give a reference in the bibliography or describe the single species, *A. voskresenskii* Lange, 1975. The description of *L. longicaudatus* is very brief. It is grouped in *Loftacarus* rather than *Amuracarus* because of the apparent absence of both a proteronotal shield and a thickened cuticular strip between the bases of setal pair *J3*.

The following 2 nominal species are included in *Loftacarus: L. longicaudatus* (Balogh and Csiszár, 1963) **n. comb.**, Argentina—NTc; *L. siefi* **n.sp.**, South Australia—Aa.

Loftacarus siefi n.sp.

Figs. 10-18

Female

General appearance and measurements: Dull ivory-white, with shields and extremities of legs tinged with pale brown. Extremities of chelicerae and external malae, and most hysteronotal setae are pitch-black. Most other setae are deep brown. A few setae and claws pale brown. Idiosomal length 700 (2, 695 and 700); appendage lengths (for 700)—*ch* 47.5, *pa* 245, *I 635, II* 470, *III* 465, *IV* 640; telofemur breadths—*pa* 37.5, *I* 85.0, *II* 80.0, *III* 57.5, *IV* 70.0.

Prosternum: Gnathosoma drawn (Fig. 13) is dorsoventrally squashed. Palp coxite seta *cd* shorter but stouter than seta *ao*1 and lying just dorsal to palp. Seta *ao1* is simple and setose. Coxosternal seta *Id* shorter but stouter than seta *ao1* and lying just dorsal to leg I. On coxite IV there is a median seta (*IV3m*) in the distal whorl.

Proteronotum: Apodemes extend anteriorad from setal bases *j2* and *s2*. Proteronotal shield is absent.

Opisthosternum: Shields around genital orifice only vaguely delineated. Describing genital setae is difficult because ovipositor only partially extruded. All genital setae are slightly stouter at base than the aggenital setae of file *Jg*. Setae *dg1, mg1* and *mg2* are longer than the aggenital setae and appear to be rigidly straight.

Hysteronotum: Shields not so clearly delineated as drawn. Adaxial setae hardly foreshortened at all because of the angle of their axes (Fig. 10). Conspicuous apodeme at base of seta *J3*. Larger setae are ciliate.

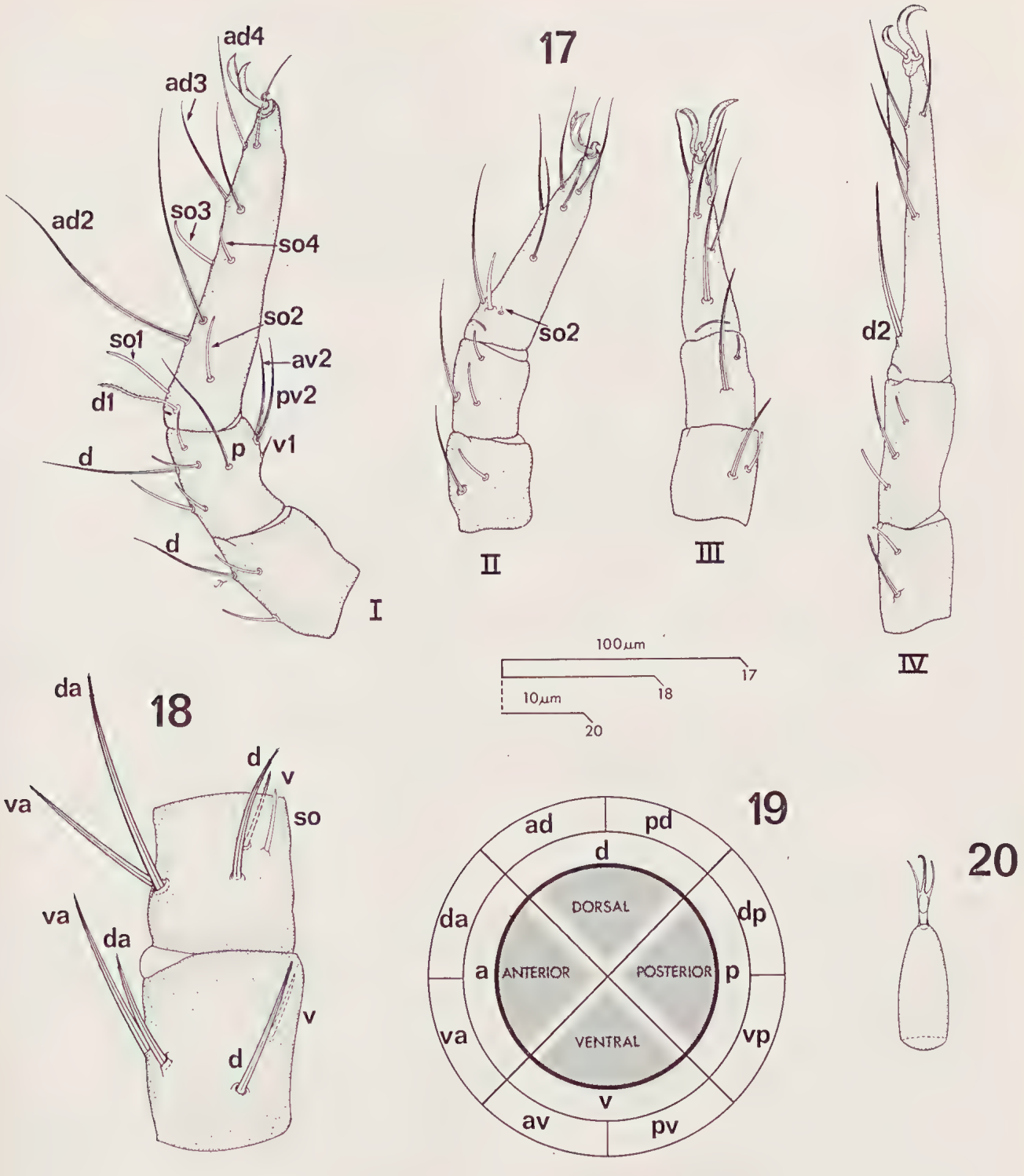
Appendages: Movable cheliceral digit carries two parallel rows of teeth. Setae: *ch* (2), *pa* (0-2-1-3-18), *I* (0-4-6-5-6-39), *II* (1-5-6-5-7-27), *III* (2-2-4-4-6-31), *IV* (3-2-3-4-5-28). On tarsus I some ventral setae and the *d*4 pair are plasmic setae. On tibia I, seta *v*1 unusually slim and short. Solenidia: *pa* (0-0-1), *I* (2-4-4), *II* (1-2-2), *III* (1-1-0), *IV* (1-2-0). Solenidium *so*2 on tarsus II is very small.

Eggs: None seen.

Male

Measurements and spermapositor (otherwise as female): Idiosomal length 765(1). Spermapositor bears 10 pairs of setose setae. All genital setae are shorter than aggenital setae. Some genital setae in file *pg* appear longer than other genital setae: it has not been established whether this is true or if it is an impression related to the angle of their axes.

Material examined: Holotype female (N197646), paratype female (N197647) and allotype male (N197648), moss and litter under *Eucalyptus obliqua*, sclerophyll forest, Mt. Lofty, 9.5.1974, D. C. Lee.



Figs. 17-20—Appendages. 17 and 18, *Loftacarus siefi* n.sp., female: 17, legs, except for tibia I, dorsal setae on genua, tibiae and tarsi; 18, telofemur III and genu III, all setae. 19: zones of appendage surface. 20: *Protoplophora palpalis* Berlese, tarsus II.

Distribution: South Australia—Aa: Mt. Lofty, sclerophyll forest, 3(2/8).

Remarks: The other member of the genus, *Loftacarus longicaudatus,* is known only by attributes of the notum. There are a few apparent differences in the relative sizes of its notal setae and those of *L. siefi,* on which they appear somewhat shorter and stouter. The best diagnostic attribute is that seta *Z*1 is longer on *L. siefi,* being about 0·75 × the distance between setal bases *Z*1 and *J*1, while on *L. longicaudatus, Z*1 is about 0·25 × this distance.

Family PALAEACARIDAE Grandjean

Palaeacaridae Grandjean, 1932b: 426.
Ctenacaridae Grandjean, 1954a: 428, **n.syn.**

Type-genus: *Palaeacarus* Trägårdh, 1932, 2.

Diagnosis: Bifemorata. Gnathosternal seta *ao*1 simple, ciliate or pectinate. Proteronotal shield present and extensive enough to carry all proteronotal setae. No bilobed refractile lining to a recess under rostrum. Some hysteronotal setae conspicuously stouter than others, with seta *Z*2 subequal to or longer than *J*3 and conspicuously displaced forward (*Z*1-*Z*2:*J*1-*J*2 = 0·25-0·5:1). Aggenital file *Jg* with 7 setae of which *Jg*1 is hammer-like or claw-like. On tarsus I, seta *d*1 distad to solenidium *so*1 or even *so*4, simple or lanceolate, may be considerably shorter than *so*1. Tibia II with 1 solenidium. Pretarsus with 2 or 3 claws, central claw may or may not be less than quarter the length of lateral claws.

Remarks: Palaeacaridae, as presented here, newly includes members of the Ctenacarinae: Grandjean, 1954c: 198, thereby further separating the latter from the Adelphacarinae and Aphelacarinae, which are here regarded as a single separate family (see remarks on Bifemorata). But, as pointed out below in the remarks on the Ctenacarinae, there are similarities between it and the Adelphacaridae. Possibly the Adelphacaridae should in the future also be included under the Palaeacaridae. Of the two palaeacarid subfamilies only ctenacarines were collected in the present study, so the Palaeacarinae is briefly considered here. Palaeacarinae includes two genera: *Palaeacarus* Trägårdh, 1932 (= *Tragardhacarus* Zachvatkin, 1945a) and *Palaeacaroides* Lange, 1972. It is known from the Holoarctic Region.

Subfamily CTENACARINAE Grandjean

Ctenacaridae Grandjean, 1954a: 428.

Type-genus: *Ctenacarus* Grandjean, 1939.

Diagnosis: Palaeacaridae. Internal mala consists of a broad proximal half and a slim distal half, the former carries all three adoral setae, with setal bases *ao*2 and *ao*3 posteriorad to base of external mala. Seta *ao*1 sparsely ciliate, ciliate or pectinate. Seta *d*1 on tarsus I never lanceloate, is either tapering or blunt ended and distad to solenidium *so*4.

Distribution: In the Northern temperate regions it is known from an area bounded by Tangiers (Pm), East Germany (Pe), Ukrainian S.S.R. (Pe), Turkmen S.S.R. (Ps) and Japan (Pc). Also it includes the only Bifemorata known from the tropics (Brazil and Venezuala—NTb; Rhodesia—Ee) as well as the below record from South Australia (Aa).

Remarks: Because of the long thick hysteronotal setae *Z*2 and *J*3 with *Z*2 conspicuously displaced forward, *Ctenacarus* looks superficially like *Palaeacarus*. This similarity is even stronger in other ctenacarine genera with less extensive hysteronotal shields and ciliate setae *Z*2 and *J*3. But because of similarities in the setae of tarsus I and in the internal malae and oral setae, Ctenacarinae has in the past been grouped with the Adelphacaridae. Here the hysteronotal similarities and those of aggenital setae *Jg*1 are regarded as important enough to regard *Ctenacarus* as not only superficially similar to, but infact more closely allied to *Palaeacarus* than *Adelphacarus* or *Aphelacarus*. The genera in this subfamily, especially *Gilarovella* and *Neoctenacarus*, are quite similar to each other. The following 4 nominal genera are included in the Ctenacarinae: *Beklemishevia* Zachvatkin, 1945b; *Ctenacarus* Grandjean, 1939; *Gilarovella* Lange, 1974; *Neoctenacarus* Moritz, 1974.

CTENACARUS Grandjean

Ctenacarus Grandjean, 1939: 543.

Type-species: *Palaeacarus araneola* Grandjean, 1932, by original designation.

Grandjeanacarus Zachvatkin, 1945b: 70.

Type-species: *Palaeacarus araneola* Grandjean, 1932, by original designation.

Diagnosis: Ctenacarinae. No ciliate hysteronotal setae. Setae *J*3, *Z*2 and *Z*6 simple or have inconspicuous paired hyaline flaps running parallel to main setal axis. Seta *J*6 is leaf-like, having conspicuous paired hyaline flaps. Setae *J*4, *J*5 and *Z*5 subequal in length to *Z*1. Opisthosternal chaetotaxy hypertrichous—e.g. 8*Sg*.

Distribution: Possibly cosmopolitan, only one nominal species (so see *C. araneola* distribution) but may be another species in Oregon—Nc. Found on ground, in dry or swampy environments, in soil mosses and other low plants and in a termite nest.

Remarks: Ctenacarus is easily distinguished from other genera in the subfamily by the form of its hysteronotal setae. *Beklemishevia africanus* (Mahunka, 1974: 206) **n.comb.** from Rhodesia was included in *Ctenacarus*. It is known only by attributes of the notum, although the venter is recorded as being as "Grundtypus". It is not confidently distinguishable from the type, and only other known species, *B. galeodula* Zachvatkin, 1945b. There is apparently a second, unnamed species of *Ctenacarus* from Oregon (Krantz, 1978: 475) on which the internal mala has an anterolateral flap ventrally obscuring the base of a pilose rather than a pectinate adoral seta *ao*1.

The following 1 nominal species is included in *Ctenacarus: C. araneola* (Grandjean, 1932b).

Ctenacarus araneola (Grandjean)

Figs. none

Palaeacarus araneola Grandjean, 1932b: 417.

Ctenacarus araneola (Grandjean): Grandjean, 1954c: 248.

Ctenacarus araneola (Grandjean): Mahunka, 1977: 464.

Male

Idiosomal length 315 (9, 290-320); appendage lengths (for 320)—*ch 17.5, pa* 65, *I* 160, *II* 110, *III* 115, *IV* 190; telofemur breadths—*pa* 12.5, *I* 25, *II* 20, *III* 17.5, *IV* 20. Although movable cheliceral digit is unusually short, the cheliceral digits are robust and distally pitch-black, as are the tips of the external malae. Hysteronotal setae *J*3, *Z*2 and *Z*6 have a narrow hyaline flap on each side as wide as the diameter of the seta. In five specimens the positor was recognised and it was as decribed for the male (Grandjean 1954c: fig. 22E).

Material examined: Nine undesignated males (N19761-N19769), litter or moss and litter, under *Eucalyptus incrassata,* mallee, Ferries-McDonald Reserve, 20.6.1974, D.C. Lee.

Distribution: Venezuela (NTb). Brazil (NTb). Morocco (Pm). Algeria (Pm). Japan (Pc). Kenya (Ee). South Australia—Aa; Ferries -McDonald, mallee-broombush open-scrubland, 9(2/8).

Remarks: Specimens referred to fit Grandjean's (1954c) description of this species except that three other pairs of hysteronotal setae, besides *J*6, have hyaline flaps. This observation is considered here to either reflect the improved microscopy of interference contrast or an intraspecific variation. All nine specimens are regarded as male because none contained eggs and five apparently had spermapositors and were similar to the other four on which the positors were not recognised.

Cohort PTYCTIMA

Remarks: The grouping of mites within this taxon as by Balogh (1972) reflects a long standing classification that is still widely held to. This is despite apparently well supported conclusions by Grandjean (1967, 1969) that the Ptyctima includes three groups more closely allied to other taxa than to each other. Using Balogh's (1972) taxa these conclusions can be summarised as follows: the Protoplophoroidea are allied to the Sphaerochthoniidae (Arthronota), the Mesoplophoroidea are allied to the Eniochthoniidae (Arthronota) whilst the Phthiracaroidea and Euphthiracaroidea are allied to the Collohmanniidae (Holonota). As stated in the introduction, I intend to try and reduce the number of superfamilies and families in the Cryptostigmata. If this is done, in combination with partly following Grandjean's (1969) later conclusions, the classification becomes very unfamiliar because the superfamily names in the Ptyctima tend to have older authorities. Therefore, for the time being, I am only following Grandjean's (1967) first change in the classification; the split of the Ptyctima into two subcohorts, the Arthroptyctima and the Euptyctima. In the next stage of this study, when members of the Arthronota and Holonota are described, I will try and reach a decision about Grandjean's (1969) later conclusions. It is possible that the Ptyctima should be disbanded and its members grouped in both the Arthronota and Holonota.

Subcohort ARTHROPTYCTIMA

Diagnosis: Ptyctima. Hysteronotal shield divided into separate anterior and posterior parts, but sometimes (Mesoplophoridae) posterior hysteronotal shield reduced and difficult to distinguish from ventral shields. Anterior hysteronotal shield carries only four to eight pairs of setae. When posterior hysteronotal shield inconspicuous there is an unbroken transverse shield between the genital and anal shield. On palp coxite, seta *cd* spine-like and less than X 0·25 length of *c*2. Genua of all appendages with either no or 1 solenidium. Nymphs ptychoid with rigid shields, although not always distributed as on adult.

Remarks: The above diagnosis includes the Protoplophoroidea Grandjean, 1965 and Mesoplophoroidea van der Hammen, 1959 as used by Balogh (1972). These superfamilies are maintained here because of Grandjean's (1967, 1969) conclusions, mentioned above, that they are each allied to one of two quite distinct groups within the Arthronota. The Protoplophoroidea includes one family which is considered below because one of its species was collected in the present study. The Mesoplophoroidea is considered briefly here. Grandjean (1965) regards this superfamily as allied to the Hypochthonioidea amongst the Arthronota, partly because of the striking resemblance between the unusual gnathosternum of *Mesoplophora* Berlese, 1904 and that of *Hypochthoniella* Berlese, 1910 (= *Eniochthonius* Grandjean). Grandjean (1965) also grouped a poorly known genus, *Archoplophora* van der Hammen, in the Mesoplophoroidea, but in a distinct family. Although the gnathosternum of *Archoplophora* is not described and the genital and anal shields only resemble those of the nymphs of *Mesoplophora,* the hysteronotal structure and setation with a lack of pleural shields provisionally groups it close to *Mesoplophora.* Members of *Mesoplophora* look superficially like small Euptyctima, but with anal and genital plates similar to the Brachypylina, rather than members of the Macropylina. The similarity to the Euptyctima is because they appear to have a single, undivided hysteronotal shield, with no ability to fold up posteriorly, and a proteronotal shield which folds downward to cover only a distinct anterior forward-facing section of the genital shield, without any pleural shields to provide lateral protective wings to the join. On the other hand, the reduced

hysteronotal chaetotaxy (8 setal pairs) indicates that the hysteronotal shield is homologous with only the anterior part of the hysteronotal shield of the Euptyctima. This supports the concept of an Arthronota-like ancestor, able to fold up the posterior part of the hysterosoma, which has since lost this ability because of the posterior hysteronotal shield being reduced and merged with the ventral shields. I am postponing an evaluation of the degree of alliance between the Protoplophoroidea and Mesoplophoroidea until a later stage in this study when the Arthonota have been considered.

Family PROTOPLOPHORIDAE Ewing

Protoplophorinae Ewing, 1917: 199.

Type-genus: *Protoplophora* Berlese, 1910.

Diagnosis: Arthroptyctima. Hysteronotum clearly divided into at least 2 articulated shields, the posterior shield capable of moving up under the anterior shield. Anterior hysteronotal shield carries 4 pairs (*J*1, *Z*1, *S*1, *S*2) or 6 pairs (plus inconspicuous *J*2 and *Z*2) of setae. Large pleural shields cover space between proteronotal and genital shields when mite folded up. Genital shield flat but inclined dorsalwards from plane of anal shield and completely covered by proteronotal shield when mite folded up. If adanal shield separates genital and anal shields it is divided mid-ventrally into 2 parts. Pretarsus with 2 or 3 claws which may be unusually long. Palp genu carrying seta *d*. All genua without a solenidium. External mala is spatulate, broadening out distally to hyaline flap.

Remarks: The protoplophorids are unusual in being able to fold up their bodies posteriorly as well as anteriorly. Van der Hammen (1959) indicates that Berlese's protoplophorids, a major part of the known family, are insufficiently described. The most informative work is the redescription of *Aedoplophora glomerata* and *Cryptoplophora abscondita* by Grandjean (1954b). The classification is further confused because of the similarity between nymphs and adults and the possiblity that some attributes used to diagnose taxa, such as number of hysteronotal divisions or sutures, vary between these stages. With the exception of *Protoplophora,* all genera are recorded in tropical latitudes, only the record of *Cryptoplophora abscondita* from Algeria (Pm) is elsewhere. The extraordinary long claws of some species suggest that they may sometimes live on other animals. The following 6 nominal genera are included in the Protoplophoridae: *Aedoplophora* Grandjean, 1932a; *Arthroplophora* Berlese, 1910; *Cryptoplophora* Grandjean, 1932a; *Hauseroplophora* Mahunka, 1977; *Protoplophora* Berlese, 1910; *Prototritia* Berlese, 1916.

PROTOPLOPHORA Berlese

Protoplophora Berlese, 1910: 217.

Type-species: *Protoplophora palpalis* Berlese, 1910, by original designation.

Diagnosis: Protoplophoridae. Anterior hysteronotal shield carries 4 pairs of simple setae. Posterior hysteronotal shields carry 8 pairs of simple setae. Posterior hysteronotal shield either with two hinged divisions just posteriorad to setae *J3, Z3* and *J4, Z4* so that there are three articulating parts, or these two divisions reduced to a suture not extending to lateral margins. Lateral margins of adanal shields approximately parallel so that they meet a wide anterior margin to enclose almost a right angle. On chelicera, seta *ch2* simple and setose. On palp, distal setae shorter than tarsus. Pretarsal claws on legs less than x 0·5 tarsal length. Palp with 5 segments and relatively long (X 0·66 length of leg I).

Distribution: Previously known mainly from around western mediterranean between latitudes 30° and 40° North. The record below from South Australia is within the equivalent southern latitudes. Also recorded from Central Asia.

Found on ground in humus, litter and moss.

Remarks: Van der Hammen (1959) was of the opinion that since Berlese (1910) did not mention characters on the ventral surface of the type of *Protoplophora,* it is impossible to decide whether or not the specimen described by Grandjean (1932a) belongs to this genus. In contrast, I consider that enough attributes of the type are known (more than one hysteronotal division, simple hysteronotal setae—not hypertrichous, long palp without long distal setae, short claws) for Grandjean's grouping of his specimen in *Protoplophora* to be accepted.

The following 2 nominal species are included in *Protoplophora: P. bivaginata* Grandjean, 1932a, *P. palpalis* Berlese, 1910.

Protoplophora palpalis Berlese

Fig. 20

Protoplophora palpalis Berlese, 1910: 217.

Protoplophora palpalis Berlese: Grandjean, 1932a: 24.

Adult

Idiosomal length 185 (3, 185-190); appendage lengths (for 190)—*ch* 16, *pa* 40, *I* 60, *II* 57.5, *III* 50, *IV* 50; femur breadths—*pa* 5, *I* 13, *II* 10, *III* 9, *IV* 9. Proteronotal seta *z*2 broadly lanceolate and in its normal drooping position the surface away from the proteronotum carries a row of inconspicuous cilia. One specimen (N197610) has a recognisable positor with at least four pairs of setae and there are only two pairs of genital papillae. It also has three clearly

delineated parts to the posterior hysteronotal shield which appear to be capable of telescoping up to overlap each other. Chelicerae have three teeth on fixed digit and one tooth on movable digit, and setae *ch*1 and *ch*2 are inconspicuous and setose. The external mala is spatulate with a long stalk (X 0.6 total length) and a pyriform hyaline flap distally. All the legs are tridactyl (Fig. 20) with a refractile, curved central claw and hyaline, slim and almost straight lateral claws.

Material examined: Three undesignated adults (N197610-N197612), litter, under *Eucalyptus incrassata*, mallee, Ferries-McDonald Reserve, 20.6.1974, D. C. Lee.

Distribution: Sicily (Pm). Spain (Pm). Central Asia (Ps). South Australia—Aa: Ferries-McDonald, mallee-broombrush open-scrubland, 3(1/8).

Remarks: The specimens referred to here fit the description of the specimen from Spain by Grandjean (1932a) rather than the type. On the basis of the standard of the descriptions this may only indicate that Berlese (1910) was not so accurate. The fact that both authors represent their specimens as monodactyl is also regarded here as as inaccurate, resulting from the smallness of the mite and the use of only bright field rather than the more revealing interference contrast illumination. But it is possible that three distinct species are represented.

Subcohort EUPTYCTIMA

Diagnosis: Ptyctima. Hysteronotal shield undivided and carrying at least 12 pairs of setae. Genital and anal shields either fused together or abut onto each other. On palp coxite, seta *cd* setose and more than X 0.25 length of *c*2. Palp with 3 to 5 segments, if genu present it does not carry any setae. Genu I carries 2 solenidia. Nymphs are not ptychoid and lack shields.

Remarks: Balogh (1972) follows Grandjean (1967) and also Walker (1965) in regarding this group as made up of four families, three of which are grouped into one superfamily (Euphthiracaroidea) leaving the other family in the Phthiracaroidea. This grouping has been followed here except that the superfamilies have been reranked as families and the families as subfamilies.

Family PHTHIRACARIDAE Perty

Phthiracarea Perty, 1841: 874.

Type-genus: *Phthiracarus* Perty, 1841.

Diagnosis: Euptyctima. Clearly delineated pairs of genital and anal shields, with the grestest width of each of these 4 shields more than X 0·4 their length. Lateral hysteronotal gland absent. On tarsus I, inconspicuous seta *d3* coupled to distal face of solenidium *so4*. Bothridium has associated internal tubes. Proteronotal setal file *s* with one seta. Palp with 3 segments. Lay eggs containing strongly sculptured, pigmented prelarvae.

Remarks: Following a computer-assisted Gower's Principal Co-ordinates Analysis to study phenetic affinity amongst 39 phthiracarid species, Sheals (1969) concluded that this family included a comparatively homogeneous group. The species used represented five of the eight phthiracarid genera listed by Balogh (1972). Sheals (1969) indicated that there might be two clusters, one representing *Phthiracarus* Perty and one *Steganacarus* Ewing or similar genera. Unfortunately, the species collected in this study is diagnosable as *Hoplophthiracarus*, members of which are placed between the two clusters, nearer to one or the other.

HOPLOPHTHIRACARUS Jacot

Hoplophthiracarus Jacot, 1933: 239.

Type-species: *Hoploderma histricinum* Berlese, 1908, by original designation.

Diagnosis: Proteronotal seta *j2* erect and subequal in length or longer than seta *J1*. Hysteronotum usually dimpled, carrying 15-18 pairs of setae, with only 3 pairs of pores and without conspicuous dorsal apophyses. Notal setae either tapering or parallel sided except for a ciliate tip. Anal shields carrying 2 pairs of setae in file *Ja* and 3 pairs of setae in file *Za*. At most, only 3 pairs of setae (file *Ja* and seta *Za3*) on median margin of anal shield. Seta *Za2* is the longest seta on anal shield. Femur I carries 4 setae, and genu IV carries 1 seta. On tibia IV, seta *d* may be either longer than seta *v* and uncoupled, or much smaller and coupled to a solenidium.

Distribution: Cosmopolitan. Na; NTb, NTc; Em; Pe, Pm, Ps, Pc; Os; Aa, Ap; Sk. The Antarctic is the only major region from which *Hoplophthiracarus* has not been recorded.

Found in soil, litter, moss and grass. Members of the genus have been recorded in substantial numbers from widely different environments such as *Sphagnum*-fens, deciduous and coniferous forests and high altitude *Rhododendron*-thickets.

Remarks: Hoplophthiracarus is a difficult genus to diagnose. Three of the earliest named species, including the type, are poorly known so it is not certain that the diagnosis presented above includes the entire range of attributes amongst species grouped here in the genus. Van der Hammen (1959) considered that *Hoplophthiracarus* is reminiscent of *Steganacarus* and that possibly it is only an artificial unit. On the other hand, Macfarlane and Sheals

(1965) indicate that, at that time, *Hoplophthiracarus* was only distiguished from *Phthiracarus* by having nearly erect interlamellar (*j2*) setae. Sheals (1969) included four species of *Hoplophthiracarus* in his study of phenetic affinity amongst phthiracarids. He found a close affinity between *H. nepalensis* and species of *Atropacarus* Ewing (in the *Steganacarus*-complex). The remaining three species (*H. costai*, an unnamed species from France and another from Argentina) were fairly widely scattered between the *Hoplophorella* Berlese cluster (in the *Steganacarus*-complex) and the *Phthiracarus* cluster. Sheals (1969) concluded that "as defined at present, the genus *Hoplophthiracarus* is not a natural group" and any resolution of the problem by making a nomenclatural division would require a study of the type of the genus.

One attribute often used to distinguish phthiracarid genera, flattness as opposed to the protrusion of the anal shields, has not been included in the above diagnosis. This is because the species described below has a mainly flat anal shield but with a protruding median margin (Fig. 28), which in some preserved specimens does not protrude downwards beyond the ventral margins of the hysteronotal shields, whilst in other specimens it conspicuously protrudes.

Two species, *Phthiracarus hamatus* Hammer, 1973 from the Tonga Islands—Ap and *P. tubulus* Hammer, 1972 from Tahiti—Ap, not included in *Hoplophthiracarus*, should be considered as possibly congeneric with species in this genus. The following 17 nominal species are included in *Hoplophthiracarus: H. cavernosus* Wallwork, 1977; *H. cazanicus* Feider and Calugar, 1969; *H. costai* Macfarlane and Sheals, 1965; *H. dactyloscopicus* Mahunka, 1978b; *H. grossmani* Jacot, 1933; *H. histricinus* (Berlese, 1908); *H. kugohi* Aoki, 1959; *H. minus* (Krivolutsky, 1965); *H. nepalensis* Sheals, 1965; *H. paludis* Jacot, 1938; *H. pavidus* (Berlese, 1913)—redescribed by van der Hammen, 1963; *H. regalis* Mahunka, 1978a; *H. robustior* Jacot, 1933; *H. shealsi* **n.sp.**; *H. siamensis* Aoki, 1965; *H. variolosa* (Berlese, 1888); *H. zebra* Balogh, 1962. There is 1 nominal subspecies: *H. histricinus nitidior* (Berlese 1923).

Hoplophthiracarus shealsi n.sp.

Fig. 21-34

Female

General appearance and measurements: Dull, straw-coloured or orange; darker specimens usually partially covered in a thin adhering layer of debris. Refractile parts (external malae, cheliceral extremities, setae and claws) paler than general integument. Much of soma covered in shallow dimples, whilst legs with very much smaller (approximately X 0.05) dimples. As well as the withdrawal of the legs and folding down of the proteronotal shield, the anal and genital shields vary in their degree of protrusion below the lateral margins of the hysteronotal shield. Hysteronotal length 600 (25, 550-665) and proteronotal length 301 (25, 270-345); appendage lengths (for 660 and 345 containing one prelarva)—*ch* 90, *pa* 120, *I* 260, *II* 240, *III* 230, *IV* 230; femur breadth—*pa* 17.5, *I* 40, *II* 32.5, *III* 27.5, *IV* 27.5.

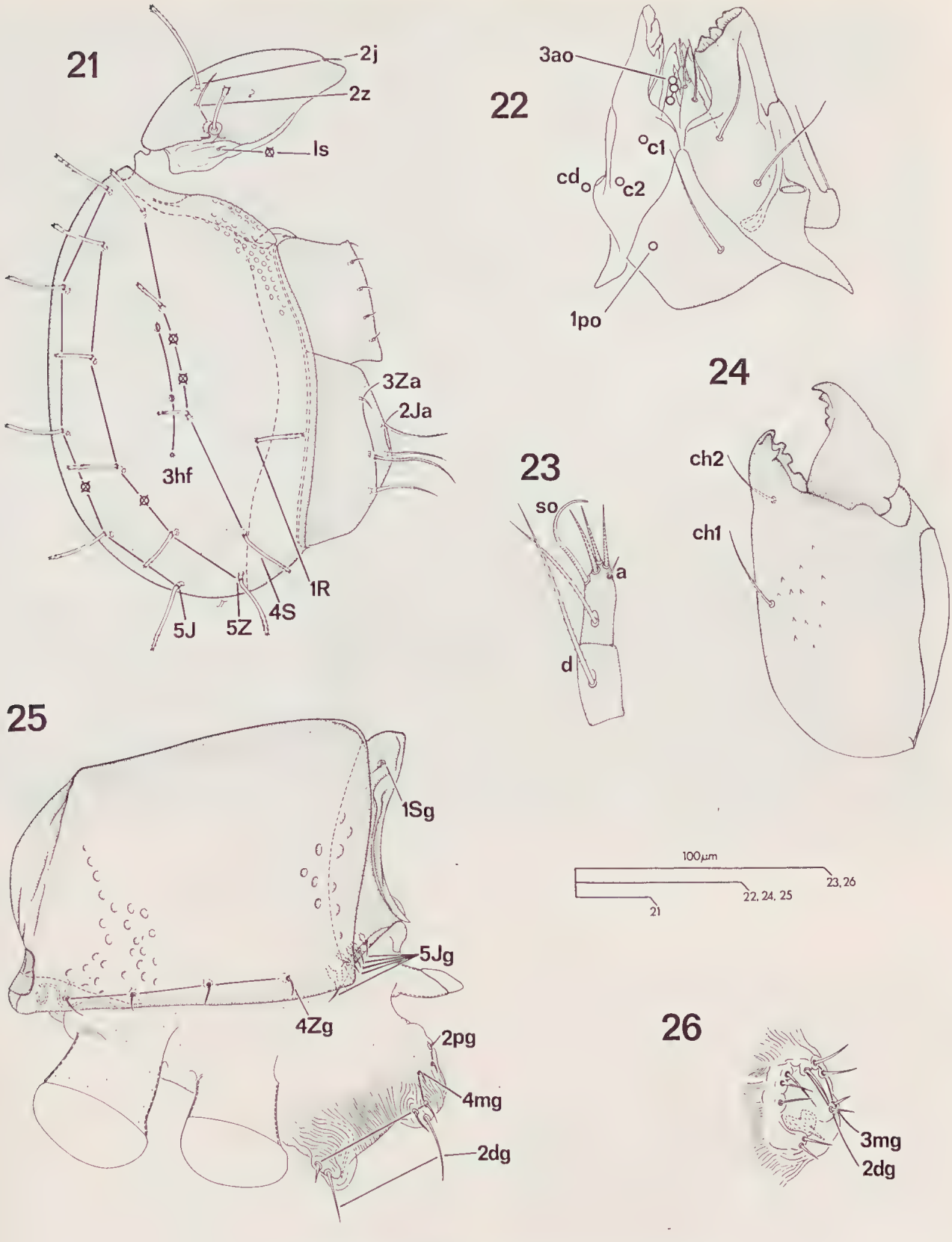
Prosternum: External malae lie in a vertical plane when in a natural position (as Fig. 31) rather than tending towards lying in a horizontal plane as when squashed (as Fig. 22). Gnathosternal setae slightly ciliate, those in file *ao* stouter and more ciliate, especially setae *ao*1 and *ao*2 (Fig. 32). Small sclerotized somal shield dorsal to where coxa II abuts onto coxa III. Coxal seta *1p* is inconspicuous.

Proteronotum: Seta *z*2 has rows of cilia distally on ventral surface (Fig. 33) which is exposed outwards and upwards when curled around in its natural position (Fig. 21). Three long hyaline bothridial tubes curled over distally; possibly some similar but short tubes also attached to bothridial chamber (Fig. 33).

Opisthosternum: Exposed anterior anal apophysis extends from left shield in all type specimens. Anterior forward facing diaxial flap of genital shield carries four setae in file *Jg*, while *Jg*5 is on exposed ventral surface (Fig. 29). In the drawing (Fig. 25) the diaxial flap is squashed so that setal file *Jg* no longer appears vertical. Furthermore, by comparing these figures it can be seen that setae in file *Jg* are much slimmer and more tapered in appearance under a light microscope as compared with an electron microscope. The two sides of both the genital and anal shield also has a thickening which fits into a notched tuberosity on the mid-venter of the posterior margin of the hysteronotum. The anterior pair of genital papillae are less than half the size of the posterior two pairs. The ovipositor carries 16 setae, amongst which two pairs are regarded as belonging to a file *pg* which has migrated distally, so that seta *pg*2 is level with *mg*1 (Fig. 25).

Hysteronotum: A zone ventralwards of seta *R* is free of dimples (Fig. 28). The 15 pairs of setae do not taper and are ciliate distally. No vestiges of setae *J*4 and *Z*4 were observed. Only three pairs of pores in file *hf*, *hf*4 apparently absent.

Appendages: Fixed cheliceral digit distally carries two parallel rows of teeth. Setae: *ch* (2), *pa* (--1-6), *I* (3-1-4-2-5-17), *II* (0-1-3-2-3-12), *III* (1-2-2-1-2-10), *IV* (1-2-1-1-2-10). Solenidia: *pa* (--0-1), *I* (2-1-3), *II* (1-1-2), *III* (1-1-0), *IV* (0-1-0). Seta *d*1 on tarsus I is



Figs. 21-26—*Hoplophthiracarus shealsi* n.sp. 21-25, female: 21, soma excluding prosternum; 22, gnathosternum; 23, part left palp, dorsal surface; 25, left chelicera, anterior surface. 25, right genital shield and ovipositor. 26, male: spermapositor.

regarded as having migrated distally to just proximad of solenidium *so* 3. Legs monodactyl, all claws have two ventral spines on proximal half.

Eggs: Amongst 25 type females, 12 contain 0 prelarvae in eggs (although some with clear patch possibly representing developing eggs), 10 contain 1

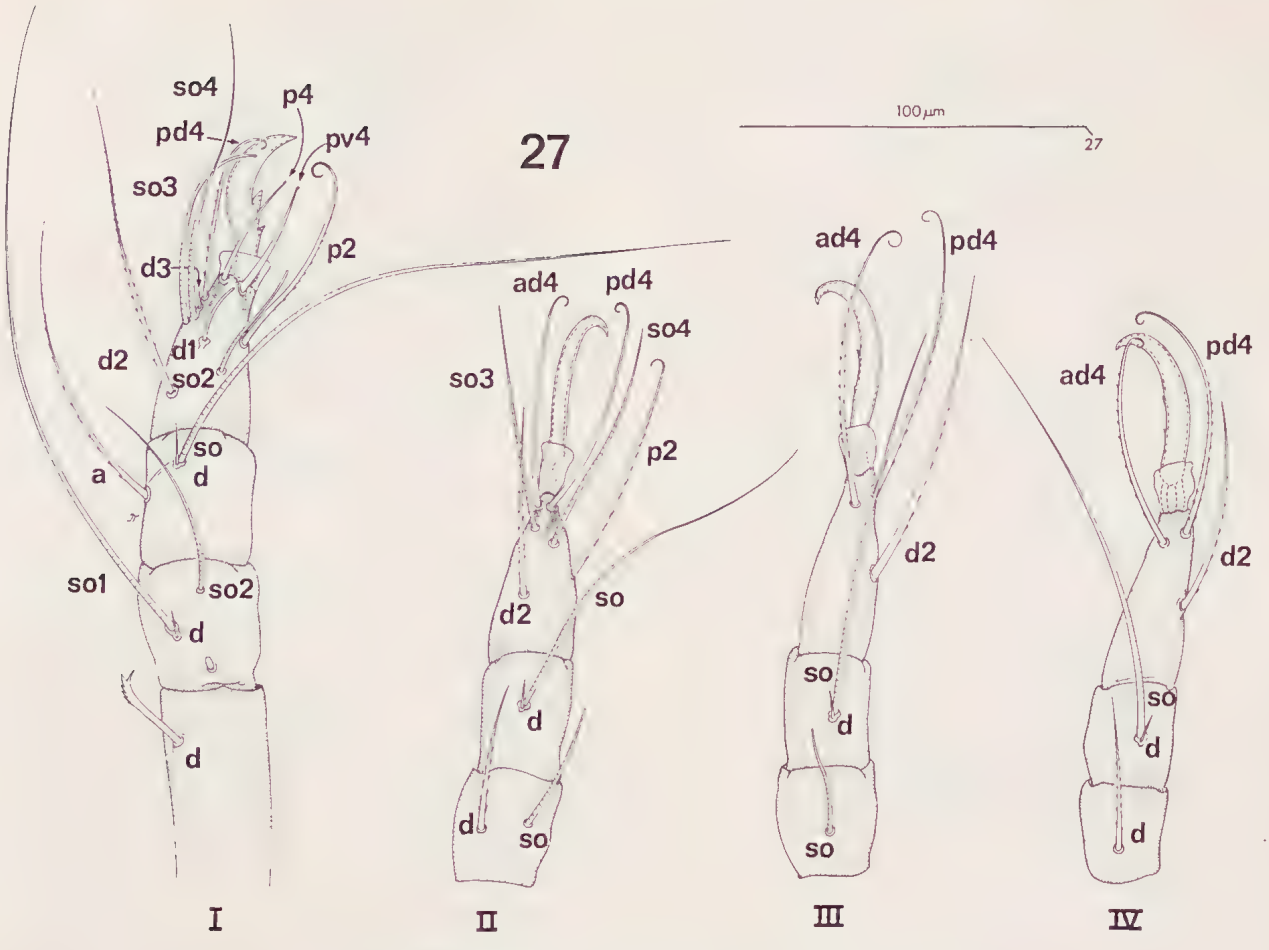


Fig. 27—*Hoplophthiracarus shealsi* n.sp., legs, dorsal setae on genua, tibiae and tarsi.

prelarva, three contain 2 prelarvae. Prelarvae about 220µm long and similar to that described for *Hoplophthiracarus pavidus* by van der Hammen (1963).

Male

Measurements and spermapositor (otherwise as female): Hysteronotal length 485 (25, 425-545) and proteronotal length 250 (25, 210-280). Spermapositor carries 10 setae which are relatively even in length compared to those on the ovipositor.

Material examined: Holotype female (N197649), 24 paratype females (N197650-N197673), allotype male (N197674) and 24 paratype males (N197675-N197698), litter under *Pinus pinea,* Knott Hill Forest, 22.5.1974, D. C. Lee. Sixteen undesignated goldcoated specimens on stub ARAS2, as above except collected on 24.11.1976.

Distribution: South Australia—Aa: Knott Hill, cultivated pine forest, 319 (2/2); Mt. Lofty, sclerophyll forest, 2 (2/8).

Remarks: The diagnosis of this species is difficult because of the inadequate description of some previously named species. If the descriptions of the latter are accurate as far as they go, *H. shealsi* can be recognised by possessing the following five groups of attributes: 1—hysteronotal shield dimpled, without numerous long furrows, also lacks a conspicuous pair of posterior concavities each side of a knob-like protruberance opposing posterior edges of anal shields; 2—15 pairs of blunt, distally ciliate hysteronotal setae; 3—solenidium on tibia IV coupled with a small dorsal seta; 4—aggenital setae of file *Jg* in a straight vertical line; 5—of the two shorter adanal setae in file *Za*, *Za*1 subequal in length to aggenital setae (X 0.9-1.1)and *Za*3 subequal in length to setae in file *Ja* (X 0.9-1.1). The setal alignment of file *Jg* in a straight vertical line is only otherwise described on *H. cavernosus* amongst species of *Hoplophthiracarus,* although it does occur on *Notophthiracarus australis* Ramsay, 1966, from New Zealand—An. If further studies support the uniqueness of this species, then it may be that it is endemic to Australia although occurring in large numbers only in the litter of an introduced conifer. It should also be noted that based on the two characters used by Sheals (1969) to distinguish the two groups into which he divides his four species of *Hoplophthiracarus, H. shealsi,* by having both 15 pairs of hysteronotal setae and a coupled solenidium on tibia IV, has one diagnostic attribute of each group.

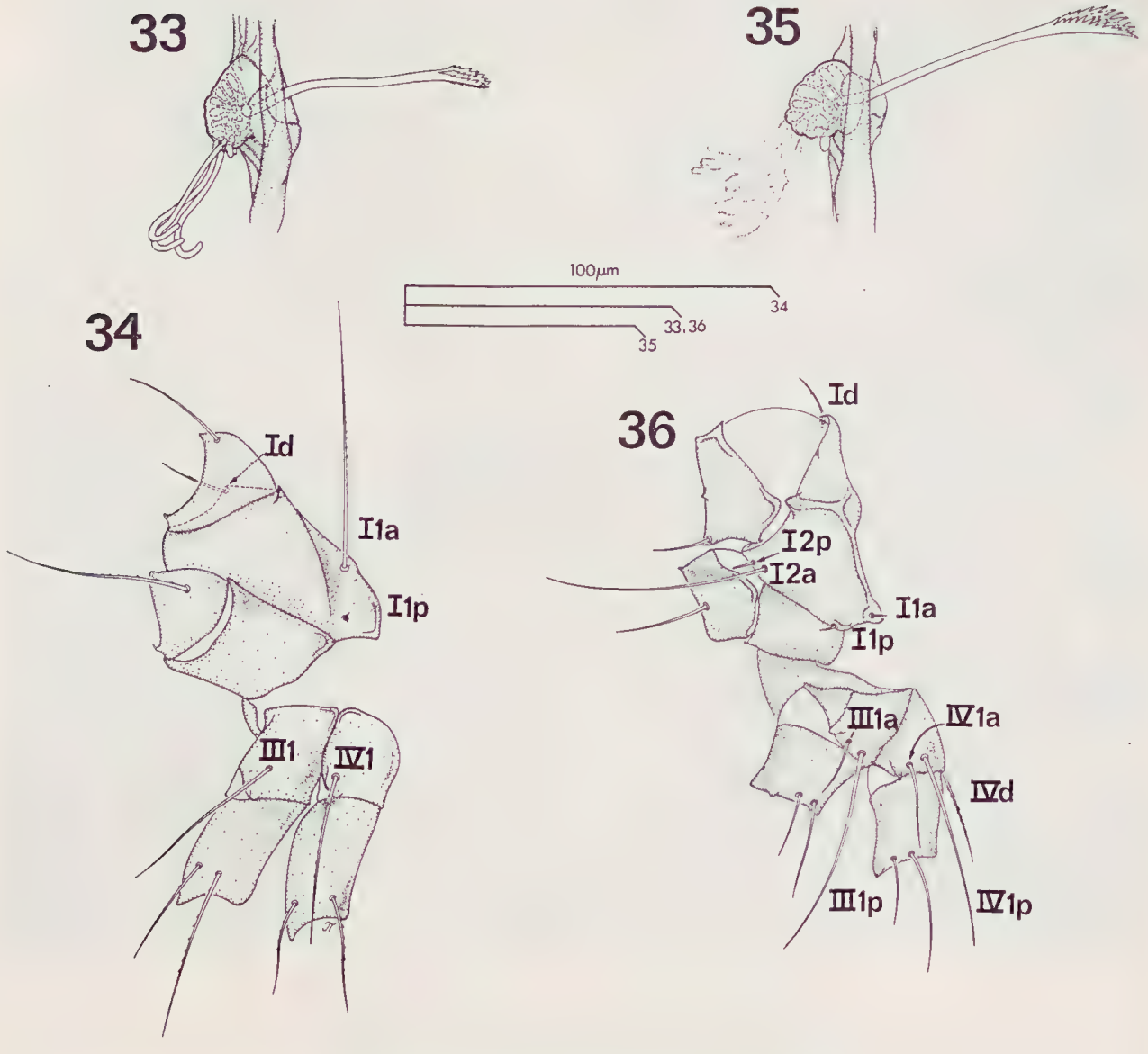
Figs. 28-32—*Hoplophthiracarus shealsi* n.sp., female: 28, hysteronotal, genital and anal shields, ×140; 29, anterior genital shields as indicated in Fig. 28, ×2100; 30, mid-venter where anal and genital shields abut, ×1400; 31, anterior proteronotum and gnathosternum, ×700; 32, parts of right internal and external malae, ×3500.

Family EUPHTHIRACARIDAE Jacot
Euphthiracarini Jacot, 1930: 214.

Type-genus: *Euphthiracarus* Ewing, 1917.

Diagnosis: Euptyctima. Genital and anal shields may or may not be separated from ventral shield by a suture, but in both cases lateral margin of ventral shields unbroken for entire length of opisthosternum. Lateral hysteronotal gland present or absent. On tarsus I, seta *d*3 conspicuous and not coupled to a solenidium. Bothridium may have associated internal filaments or, rarely, internal tubes. Proteronotal setal file *s* with 1 or 2 setae. Palp with 3, 4 or 5 segments. Either lay eggs with or without ornate chorion, or containing a strongly sculptured, pigmented prelarvae.

Remarks: The results of a computer-assisted Gower's Principal Co-ordinates Analysis of phenetic affinity amongst 53 Euptyctima species indicated that the Euphthiracaridae is not so homogeneous as the Phthiracaridae, since the first generic separation occurs at the 74 per cent rather than the 90 per cent phenon line (Sheals, 1969). In that study the 14 species of euphthiracarid, representing 7 genera, separate into three groups at the 74 per cent phenon line: two within Oribotritinae, one within Euphthiracarinae. Therefore, it appears preferable to follow Märkel (1964) and group 'non-phthiracarid' Euptyctima in one family, but maintain subfamilies equivalent to the families listed in Walker (1965). The Oribotritiinae Grandjean, 1954a and Synichotritiinae Walker, 1965 have not been collected in the present study, while the other subfamily is considered below.



Figs. 33-36—Ventral view of setae *z*2 and podosterna. *Hoplophthiracarus shealsi* n.sp., female: 33, seta *z*2 plus associated bothridial structures; 34, coxae and trochanters I-IV. *Rhysotritia wallworki* n.sp., female: 35, seta *z*2 plus associated bothridial structures; 36, coxae and trochanters I-IV.

Subfamily EUPHTHIRACARINAE Jacot

Euphthiracarini Jacot, 1930: 214

Type-genus: *Euphthiracarus* Ewing, 1917.

Diagnosis: Euphthiracaridae. Anal shield with anterior triangular corrugated area. Anogenital suture present but often limited to breadth of corrugated triangle. Anal and genital shields fused with ventral shield so that no line of demarcation separates them. Lateral hysteronotal gland present. Palp with 3 segments. Lay eggs with ornate chorion or a smooth chorion and containing a larva.

RHYSOTRITIA Märkel and Meyer

Rhysotritia Märkel and Meyer, 1959: 329.

Type-species: *Hoplophora ardua* C. L. Koch, 1841, by original designation.

Diagnosis: Bothridial flap dorsal to seta *z*2. Distance between setal bases *j*2-*j*2 less than twice distance between setal bases *j*2-*z*2. Seta *j*2 approximately twice as long as *j*1. On genital shields, between 7 and 11 pairs of setae. Posterior corrugations on anal shields. Pore *Zaf* subcircular and never nearer triangular corrugated area than it is to seta *Za*1. Seta *Ja*1 recognisable but small. Setae *Ja*2 and *Ja*3 shorter than *Za*1 and *Za*2. On genu IV, no solenidium.

Distribution: Widespread. NTc; Pe, Ps; Aa, Ap. Species from North America, previously included in *Rhysotritia*, are now grouped in *Microtritia* Märkel, 1964.

Found in decaying wood, humus and moss. A number of ecological studies indicate some members of this genus occur in the deeper more compact layers of the lower fermentation zone and the upper part of the humus zone, whilst some species of Phthiracaridae occur in zones above them.

Remarks: One attribute used by Balogh (1972) to distinguish *Rhysotritia* is not comprehensive enough because *R. clavata sextiana* has only one pair of setae on both trochanters III and IV. The diagnosis used here is based on that of Märkel (1964).

The following 4 nominal species are included in *Rhysotritia: R. ardua* (Koch, 1841); *R. calvata* Märkel, 1964; *R. duplicata* (Grandjean, 1953); *R. wallworki* **n.sp.** There are 4 nominal sub-species: *R. ardua otaheitensis* Hammer, 1972; *R. ardua penicillata* Pérez-Inigo, 1969; *R. calvata sextiana* Lions, 1966; *R. duplicata limbata* (Märkel and Meyer, 1959).

Rhysotritia wallworki n.sp.
Fig. 35-42

Female

General appearance and measurements: Dull, ivory-white with pinkish edges to shields. Refractile parts (external malae, cheliceral extremities, setae and claws) paler than general integument. Most of soma covered by fine pores (Fig. 41). Hysteronotal length 390 (5, 360-415) and proteronotal length 240 (5, 225-255); appendage lengths (for 410 and 245), *ch* 60, *pa* 97.5, *I* 185, *II* 170, *III* 167.5, *IV 167.5; femur breadth—pa* 15.5, I 37.5, *II* 27.5, *III* 25, *IV* 22.5

Prosternum: External malae are curved, tending to form a cylinder around the chelicerae. Only seta *cd* on gnathosoma appears to be even slightly ciliate. Long sclerotized somal shield dorsal to and between coxae II and III. Coxa I as drawn (Fig. 36) is swivelled round so that anterior surface is facing ventralwards.

Proteronotum: Seta *z*2 has rows of cilia distally on ventral surface (Fig. 35) which is exposed forwards and outwards when curled around in its natural position (Fig. 37). A number of granular filaments extend inwards from bothridial chamber (Fig. 35) and disappeared when cleared. Presumably these are "tracheoles". From their appearance in this species it is possible that they are the outer layers of a series of tubes. Only two ridges radiate forward from bothridium.

Opisthosternum: Small anterior forward facing diaxial flap on genital shield. All setae in file *Jg* are in a straight horizontal line inside grooves on opposing faces of midventral division between genital shields. There are small interlocking corrugations at posterior end of anal shield. Ovipositor carries 12 setae; apparently file *pg* is unrepresented. The positor is assumed female because of the large size of the setae in file *dg* (Fig. 40).

Hysteronotum: The 14 pairs of setae are slighty ciliate and tapered. The fine pores represented by spots (Fig. 41) show up as lines in profile, possibly being narrow ducts running as deep as the long outer chambers at the setal bases. Five pairs of pores in file *hf,* with a conspicuous duct to hysteronotal gland opening near *hf*3.

Appendages: Chelicerae with relatively small teeth. Setae: *ch* (2), *pa* (--2-8), *I* (5-1-3-3-5-17), *II* (0-1-3-3-4-13), *III* (2-2-2-23-11), *IV* (3-2-1-1-2-9). Solenidia: *pa* (--0-1), *I* (2-1-3), *II* (1-1-2), *III* (1-1-0), *IV* (0-1-0). All solenidia on genua and tibiae are coupled with a dorsal seta, but the bases of the couples appear to be discrete rather than merged as in *Hoplophthiracarus shealsi* described above. Seta *d*1 on tarsus I is stout with annular wrinkles and is regarded as having migrated distally to be level with solenidium *so*4. The setal pair *av*1 and *pv*1 on tarsus II are absent. Each pretarsus with a single claw having 2 inconspicuous ventral spines on proximal half.

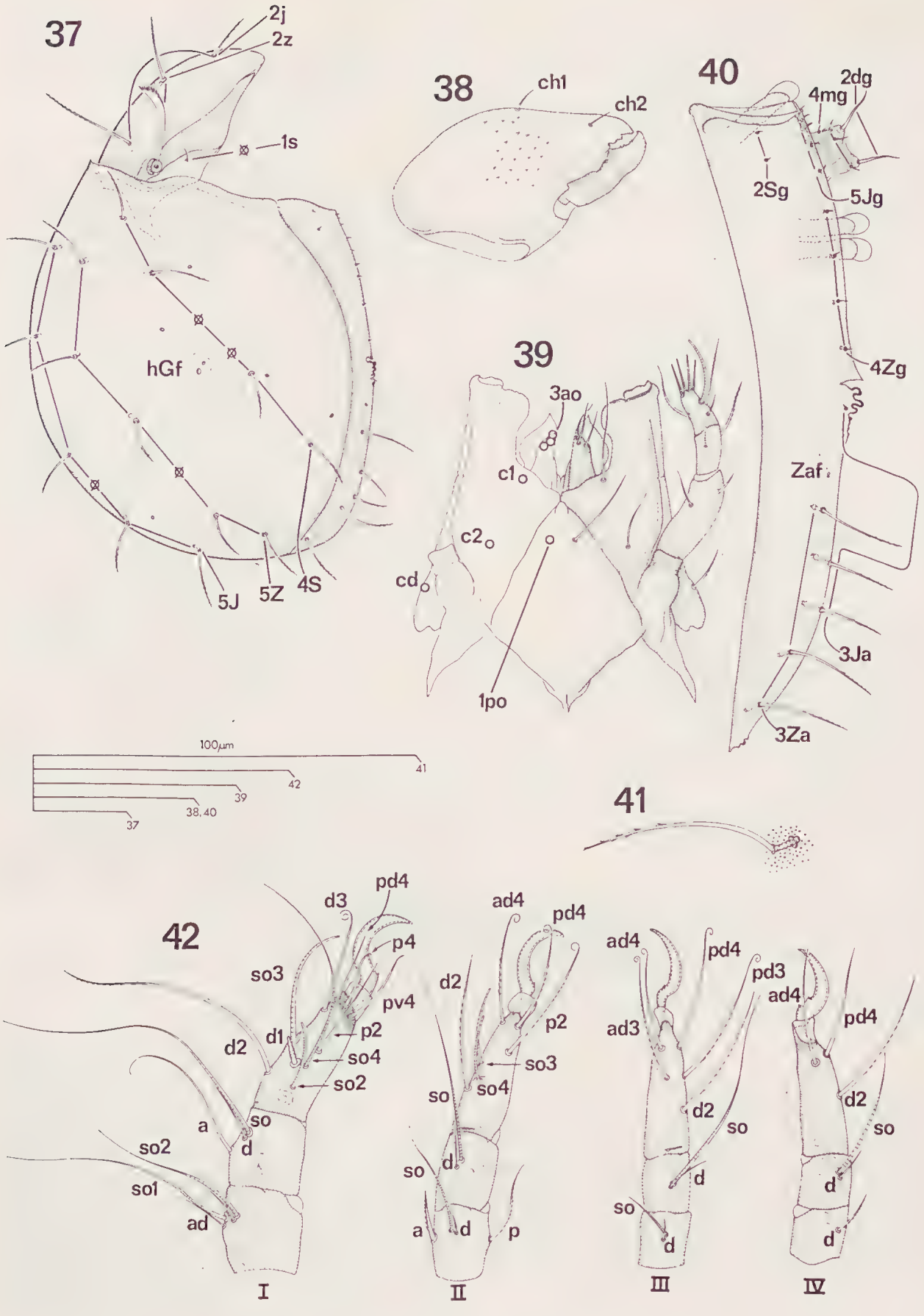
Male

Unknown.

Material examined: Holotype female (N197699), 2 paratype females (N1976100 and N1976101), litter under *Acacia sophorae,* Piccaninnie Ponds Reserve, 3/7/1974, D. C. Lee. Two paratype females (N1976102 and N1976103) litter and grass under *Eucalyptus viminalis,* Chambers Gully, 12/6/1974, D. C. Lee.

Distribution: South Australia-Aa: Piccaninnie Ponds, coastal shrubland, 3(2/8); Chambers Gully, savannah woodland, 2(1/8).

Remarks: Considering the similarity between the species of this genus and the relatively substantial differences between some subordinate subspecies and their type subspecies, it is difficult to decide how to classify new material. *R. wallworki* can be clearly distinguished from *R. duplicata* which is tridactyl, has an extra ridge running forward from dorsal margin of bothridial flap, and setae *av*1 and *pv*1 present on tarsus II. *R. ardua* differs in being either bidactyl or tridactyl and having a slim seta *z*2. On the other hand *R. clavata* is similar, but *R. wallworki* is distinguished by four attributes: longer cilia on notal setae including *z*2, 11 pairs of setae on the genital shields, only a very indistinct notch in the bothridial flap and 17 setae on tarsus I. But it should be noted that two of the characters involved, the



Figs. 37-42—*Rhysotritia wallworki* n.sp., female: 37, soma, excluding prosternum; 38, left chelicera, anterior surface; 39, gnathosternum; 40, right anogenital shield plus partially extruded ovipositor; 41, hysteronotal seta *J*3; 42, dorsal setae on genua, tibiae and tarsi.

setation of the genital shield and tarsus I, vary within the species *R. clavata* (including *R.c.sextiana),* although not to the extent of overlapping with *R. wallworki.*

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EVOLUTIONARY SYSTEMATICS OF *XENYLLA*. XII. REDESCRIPTION OF *X. OCCIDENTALIS* WOMERSLEY AND A COMPARISON OF THE CHAETOTAXY OF *X. ARENOSA* UCHIDA AND TAMURA AND *X. LITTORALIS* WOMERSLEY (INSECTA: COLLEMBOLA)

by

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ABSTRACT

GAMA, M.M. da. 1981. Evolutionary systematics of *Xenylla*. XII. Redescription of *X. occidentalis* Womersley and a comparison of the chaetotaxy of *X. arenosa* Uchida and Tamura and *X. littoralis* Womersley (Insecta: Collembola). *Rec. S. Aust. Mus. 18*(10): 223-226.

X. occidentalis is redescribed from Womersley material; the chaetotaxy of *X. arenosa* is given showing it to be distinct from *X. littoralis*. The phylogenetic position of these species is also considered.

OBSERVATIONS AND DISCUSSION

Xenylla occidentalis Womersley, 1934

(Fig. 1)

Material examined

Western Australia: Red Hill, Kalamunda, on fungus, D.C.S., 30.V.1931, 6 specimens identified by Womersley.

Redescription

Body length: 0.56-0.74 mm Blue. Cutaneous granulation relatively coarse.

Dorsal chaetotaxy showing the following characters.

Head: all setae present; L_1 equal in length to L_3.
Th.II-III: all setae present and central ones arranged in five rows (characters h_1, h_2). There are 2 S.s. on each side, one in position P_4.
Abd.I-III: S.s. = P_6; p_5 absent.
Abd.IV: S.s. = P_5.
Abd.V: S.s. = P_3; a_2 present.

Ventral chaetotaxy presenting the following features
Head: all setae present.
Th.II-III: without setae (character t).
Abd.II: p_1 and p_2 absent (character v).
Abd.III: without medial setae nor median seta.

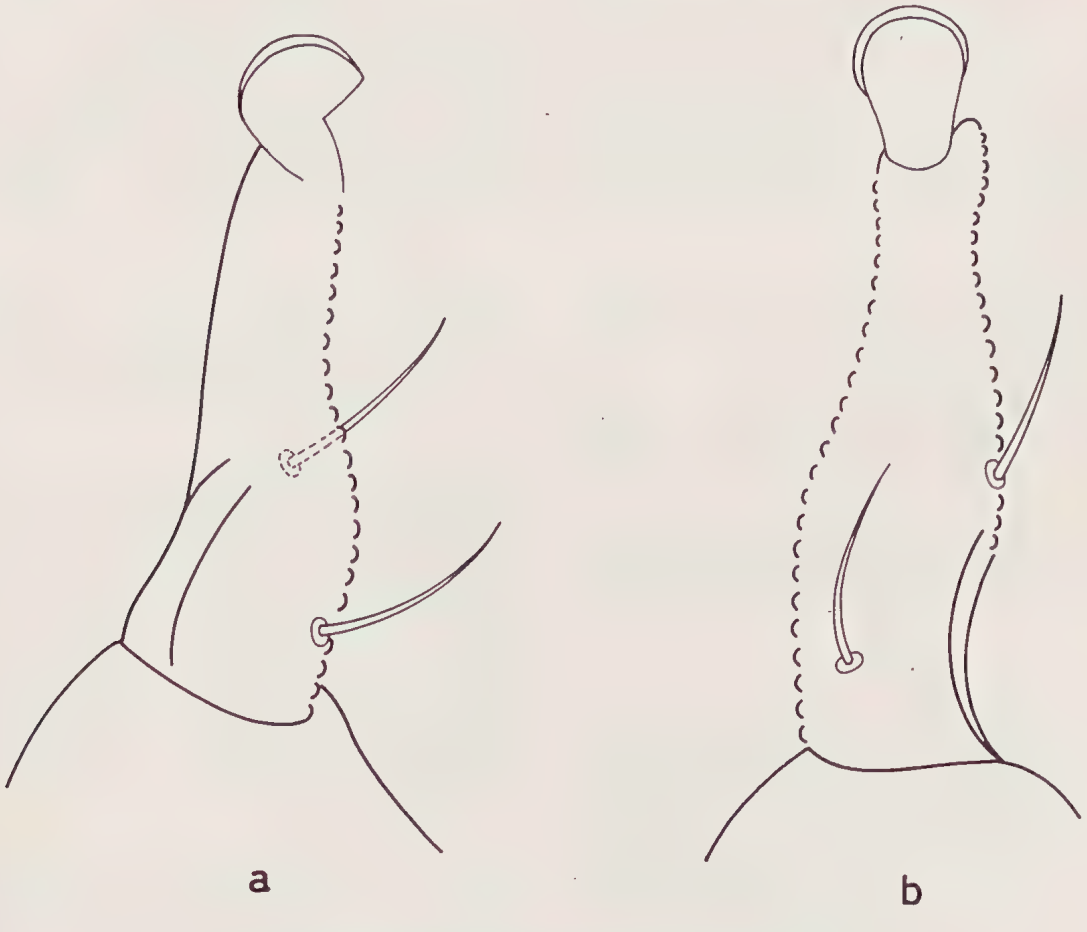

Fig. 1—*Xenylla occidentalis*. a—Mucrodens in profile; b—Mucrodens, postero-dorsal view.

Abd.IV: the following setae absent—m_1 (character a_4), m_2 (character a_5) and m_3 (character a_6).

Antenna IV with four cylindrical sensillae, of which three are in outer dorsal position and one is in the inner dorsal position.

5 + 5 eyes.

Unguis without inner tooth. Tibiotarsus with two dorsal and two ventral long, clavate tenent hairs. Tenaculum with 3 + 3 barbs. Mucro spoon-shaped (Fig. 1), about 1/4-1/5 of length of dens, separated from it, which has two setae. The mucro is about half as long as unguis III. Anal spines not able to be observed.

Systematics and evolution

The chaetotaxic characters (h_1, h_2, t, v, a_4, a_5, a_6) mentioned in the redescription place this species in the position indicated in the phylogenetic tree (Gama and Greenslade 1981).

Xenylla arenosa Uchida and Tamura, 1967

(Fig. 2)

Material examined of *X. littoralis* (see Gama 1980a)

South Australia: Yorke Peninsula, Jolly's Beach, 7 specimens (identified by Gama); Yorke Peninsula, Royston Head, 8 specimens (identified by Gama); Christies Beach, 4 specimens (identified by Womersley); Marino Rocks, 2 specimens (identified by Womersley).

Western Australia: Rottnest Island, 1 cotype (identified by Womersley).

Japan, Cape Tachimachi, 9 specimens (identified by Gama).

Material examined of *X. arenosa:* Japan, Akkeshi, 3 paratypes, leg. H. Tamura, 28.VI.1965.

Systematics and evolution

X. arenosa belongs to the most primitive group of species *(welchi, malayana, portoricensis, bellingeri, subbellingeri, thibaudi* and *littoralis)* in which the central setae on thoracic tergites II-III are arranged in three rows (absence of characters h_1h_2)—see phylogenetic trees in Gama 1980b and Gama and Greenslade 1981. As well, these species have no setae on thoracic sternites II-III (character t).

Dorsal chaetotaxy (Fig. 2): there are supernumerary setae, not represented in Figure 2, on the thoracic and abdominal tergites, principally on th.I, lateral parts of th.II-III and abd. I-IV, and one can observe a differentiation into macrochaetae and microchaetae.

Head: p_1 absent (character b); L_1 equal in length to L_3; L_0 as long as L_1 and L_3 (unusual in the genus *Xenylla).*
Th. II-III: central setae arranged in three rows; m_3 absent (character k); there are 2 S.s. on each side, one of which is in position P_4.
Abd. I-III: S.s. = P_6; p_5 present.
Abd. IV: S.s. = P_5; m_3 absent (character o); a_3 present.
Abd. V: S.s. = P_3; a_2 present.
Ventral chaetotaxy:
Head: p_1 and m_3 absent (character r, s).
Th. II-III: without setae (character t).
Abd. II: all setae present.
Abd. III: without medial setae nor median seta.
Abd. IV: all setae appear to be present though difficult to distinguish.

Comparison of the chaetotaxy of *X. arenosa* with that of *X. littoralis*

A study of the descriptions of these two halophilous species, the former known from Japan and the latter from Australia and Japan (Gama 1980a, p. 123) might lead one to think that they are one and the same. For a brief comparison of the adaptive characters between *X. arenosa* and *X. littoralis* (see Gama 1980a, p. 123-125).

However, an examination of their chaetotaxy indicates that they are distinct species separated by the following nonadaptative characters (Fig. 2, this paper, and Fig. 1, in Gama 1980a).

Dorsal chaetotaxy: on the head p_1 is absent in *X. arenosa* (character b) and present in *X. littoralis;* in this latter species L_1 is longer than L_3 (character f), whereas in the former these two setae are equal in length. On the th. II-III m_3 is absent in *X. arenosa* (character k), and present in *X. littoralis.* On the abd. IV m_3 is absent in *X. arenosa* (character o) and present in *X. littoralis* in which p_3 is absent (character n), whereas in *X. arenosa* p_3 is present.

Ventral chaetotaxy: on the head p_1 and m_3 are absent in *X. arenosa* (characters r, s) and present in *X. littoralis.* On the abd. II all the setae are present in *X. arenosa,* while in *X. littoralis* p_1 and p_2 are absent (character v) and p_6 also (character w).

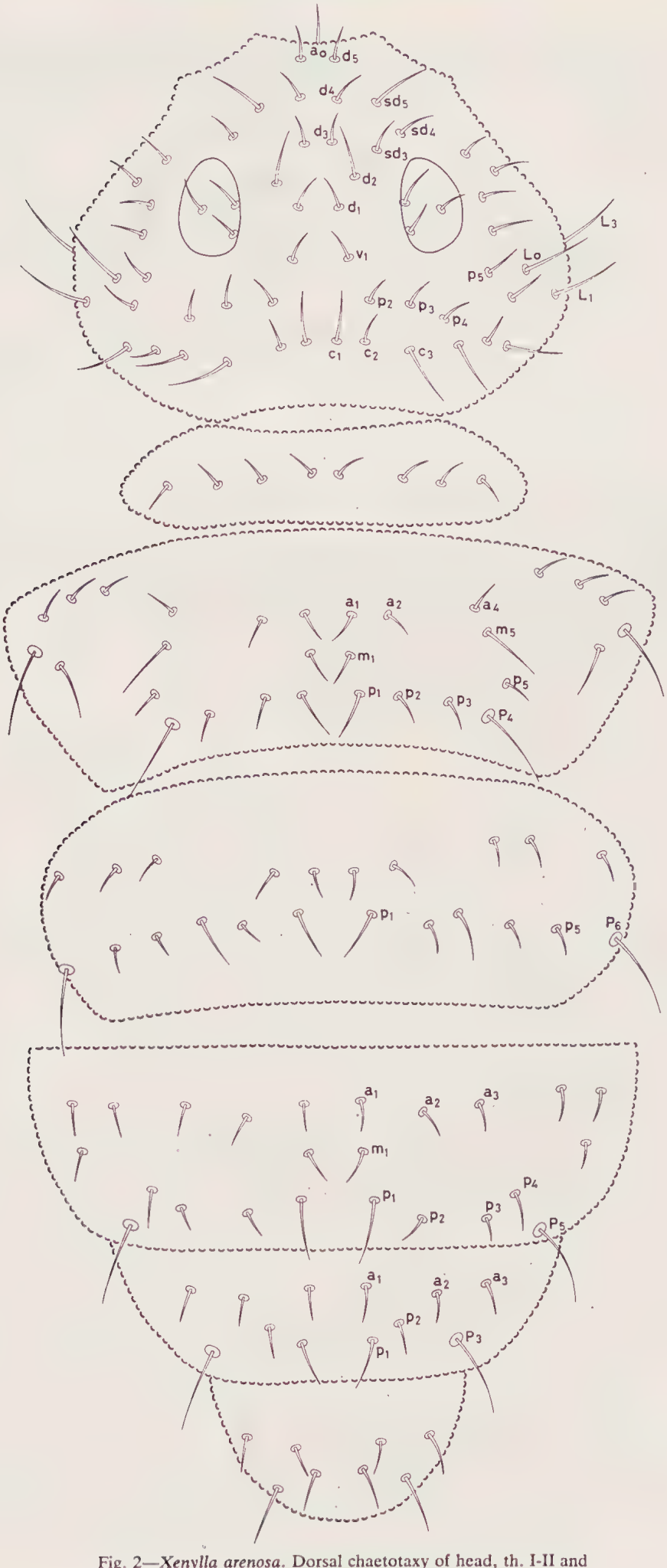

Fig. 2—*Xenylla arenosa*. Dorsal chaetotaxy of head, th. I-II and abd. I, IV-VI.

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A NEW SPECIES OF THE GENUS *CATACANTHUS* SPINOLA (HETEROPTERA: PENTATOMIDAE: PENTATOMINAE) FROM THE NEW HEBRIDES WITH MORPHOLOGICAL NOTES ON TWO OTHER AUSTRALASIAN SPECIES AND THEIR RELATIONSHIPS[1]

by

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ABSTRACT

AHMAD, I., and *KAMALUDDIN, S. 1981.* A new species of the genus *Catacanthus* Spinola (Heteroptera: Pentatomidae: Pentatominae) from the New Hebrides with morphological notes on two other Australasian species and their relationships. *Rec. S. Aust. Mus.* **18** (11): 227-233.

Catacanthus grossi Ahmad & Kamaluddin, n.sp. of the tribe Catacanthini Stål from the New Hebrides is described and its metathoracic scent gland ostioles and genitalia examined and figured. Morphological notes on two other Australasian species, *C. carrenoi* (Le Guillou) and *C. punctus* (Fabr.), are given and the three species above are compared with *C. incarnatus* (Drury) from the Oriental region and the relationships of the four species are briefly discussed.

INTRODUCTION

Gross (1976) placed the genus *Catacanthus* Spinola in his general section of Pentatominae allied to his *Menida, Piezodorus, Pentatoma & Rhynchocoris* groups for want of sufficient male specimens. Ahmad and Afzal (1978) studied the external morphology, including the metathoracic scent gland ostioles, and the male and female genitalia and also the internal anatomy including the digestive, male and female reproductive organs and the scent and salivary apparati of *C. incarnatus* (Drury) and proposed the resurrection of Catacanthini Stål within the subfamily Pentatominae Amyot et Serville.

Recently by the courtesy of Dr G. F. Gross, Principal Curator of South Australian Museum, the authors were given the opportunity to examine a unique male specimen of *Catacanthus* from the New Hebrides which differs from all other species in being a uniformly dark purplish-brown with the venter and all femora yellow in contrast to the generally patterned body of brilliant, shining colours in other species. It is described here as *C. grossi* n.sp., and the structure of its metathoracic scent gland ostioles and genitalia have been investigated.

[1]Financially supported by PARC-USDA Research Project A17-ENT-37 (FG-Pa-181).

[2]Research Officer 'STUDIES ON THE RICE INSECTS OF PAKISTAN WITH REFERENCE TO THEIR SYSTEMATICS AND PHEROMONE GLANDS' FG-Pa-310 (PK-ARS-139).

Male and female specimens of two other species, *C. punctus* (Fabricius)—also by the courtesy of Dr Gross—and *C. carrenoi* (Le Guillou) by the courtesy of Dr W. J. Knight and Mr W. R. Dolling of the British Museum (Natural History), London, were examined with special reference to the above characters, for there has been a general belief that the two species may be synonymous (Gross, personal communication). Diagrams of the male and female genitalia of *C. incarnatus* (Drury) are also given for comparison and for further clarification of the structures and the relationships of the included taxa are briefly discussed in this light. For dissections, drawings and measurements the conventional procedures, especially those used by the present authors (1976), were generally followed.

Catacanthus carrenoi (Le Guill.)

(Figs. 1-4, 12-15, 29, 31)

Raphigaster carrenoi Le Guillou, 1841, p. 262.

Pentatoma tricolor Montrouzier, 1855, p. 96.

Catacanthus carrenoi, Stål, 1876, p. 89.

Coloration: Body pale, reddish except head (excluding brownish-black eyes), pinkish ocelli, pronotum with anterior and anteriolateal margins including callosities and a wide posteriomedial portion, scutellum with basal wide portion, each corium with a large transverse spot on middle portion, clavus, legs, antennae and labium black, connexiva reddish, membrane of hemelytra light brown.

Head: Slightly broader than long; anteocular region slightly shorter than posterior portion of head including eyes; antennae with 3rd segments longer than 2nd and equal to 2¼ x basal, length of segments, 1 1.2 mm (1.2-1.5 mm), 2 3.0 mm (3.0-3.2 mm), 3 3.3 mm (3.1-3.3 mm), 4 4.5 mm, 5 4.1 mm, antennal formula 1<2<3<4; labium passing mesocoxae, basal segments shorter than bucculae, 3rd segment longest and distinctly more than 1½ x basal, length of segments 1 1.3 mm (1.3-1.5 mm), 2 2.0 mm (1.9-2.2 mm), 3 2.35 mm (2.0-2.4 mm), 4 1.75 mm (1.5-1.8 mm), labial formula 1<4<2<3; length anteocular region 1.5 mm (1.5-1.6 mm); length posterior of head including eyes

1.6 mm (1.6-1.75 mm), width 3.15 mm (3.15-3.9 mm); interocellar distance 1.7 mm (1.7-1.8 mm); interocellar distance 1.0 mm (0.9-1.1 mm).

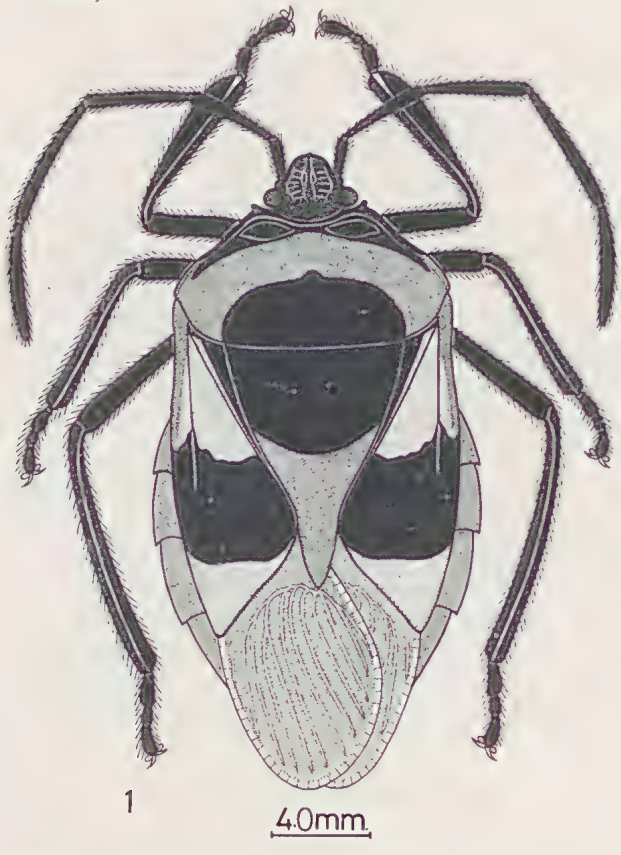


FIG. 1. *Catacanthus carrenoi* Le Guillou in dorsal view.

Thorax and Abdomen: Pronotum with humeral angles rounded, length of pronotum 4.4 mm (3.8-5.2 mm), width 10.4 mm (9.4-12.0 mm); scutellum with apical lobe narrowed, apex acute, length of scutellum 8.5 mm (8.2-10.0 mm), width 6.5 mm (6.0-7.4 mm); mesosternum slightly raised and rugulose; metathoracic scent gland ostioles (Fig. 2) small, somewhat ovate, peritremes elongated tapering anteriolateral, apically somewhat acute, evaporating area distinct; distance base scutellum-apex clavus 6.6 mm (6.2-7.6 mm); apex clavus-apex corium 4.3 mm (3.5-4.8 mm); apex corium-apex membrane 5.8 mm (5.2-6.1 mm); apex scutellum-apex membrane including abdomen 8.1 mm (7.2-9.0 mm); abdomen with basal abdominal spine only reaching hind coxae; connexiva distinctly exposed in repose; in ♀ posterior margin of 7th abdominal sternum medially shallowly folded in, laterally almost straight. Total length ♂ 24.1 mm (22.3-24.1 mm), ♀ 27.55 mm.

Male genitalia: Pygophore (Figs. 3 and 4) with dorsomedian surface deeply concave, three spinelike processes at inner side of posterior lateral margins, ventroposterior margin folded in medially, laterally distinctly sinuated, ventrolateral lobe with two spinelike fused processes, directed inward; parameres (Fig. 12) F-shaped, inner process short, outer and inner margins entire, sinuated, apex much narrowed, acute; theca (Figs. 13-15) with an unpaired dorsal blunt thumb-like large median thecal appendage, a pair of dorsal thecal appendages with lateral, horn-like, semisclerotized lobes, a pair of ventral thecal appendages proximally semisclerotized and distally sclerotized and denticulated, and a bilobed dorsal membranous conjunctival appendages with distal portion sclerotized and outwardly sinuated, vesica short, penial lobes ovate medially and outwardly fused with conjunctiva.

Female genitalia: (Fig. 29) 8th paratergites fused, medially almost straight, sub-equal to 1st gonocoxae, latter with posterior margin sinuated, 9th paratergites lobelike, elongated, outer margin medially concave, slightly passing beyond posterior margins of fused 8th paratergites, proctiger posteriorly substraight, 2nd gonocoxae broad; spermatheca (Fig. 31) with pump region medially faintly constricted, bulb with two equal elongated, fingerlike processes.

Material examined: 2 ♂, 1 ♀, N. Borneo, Philippines and New Guinea: 1911; June 1936 leg Distant, W. L. Cheesman, L. E., in British Museum (Natural History).

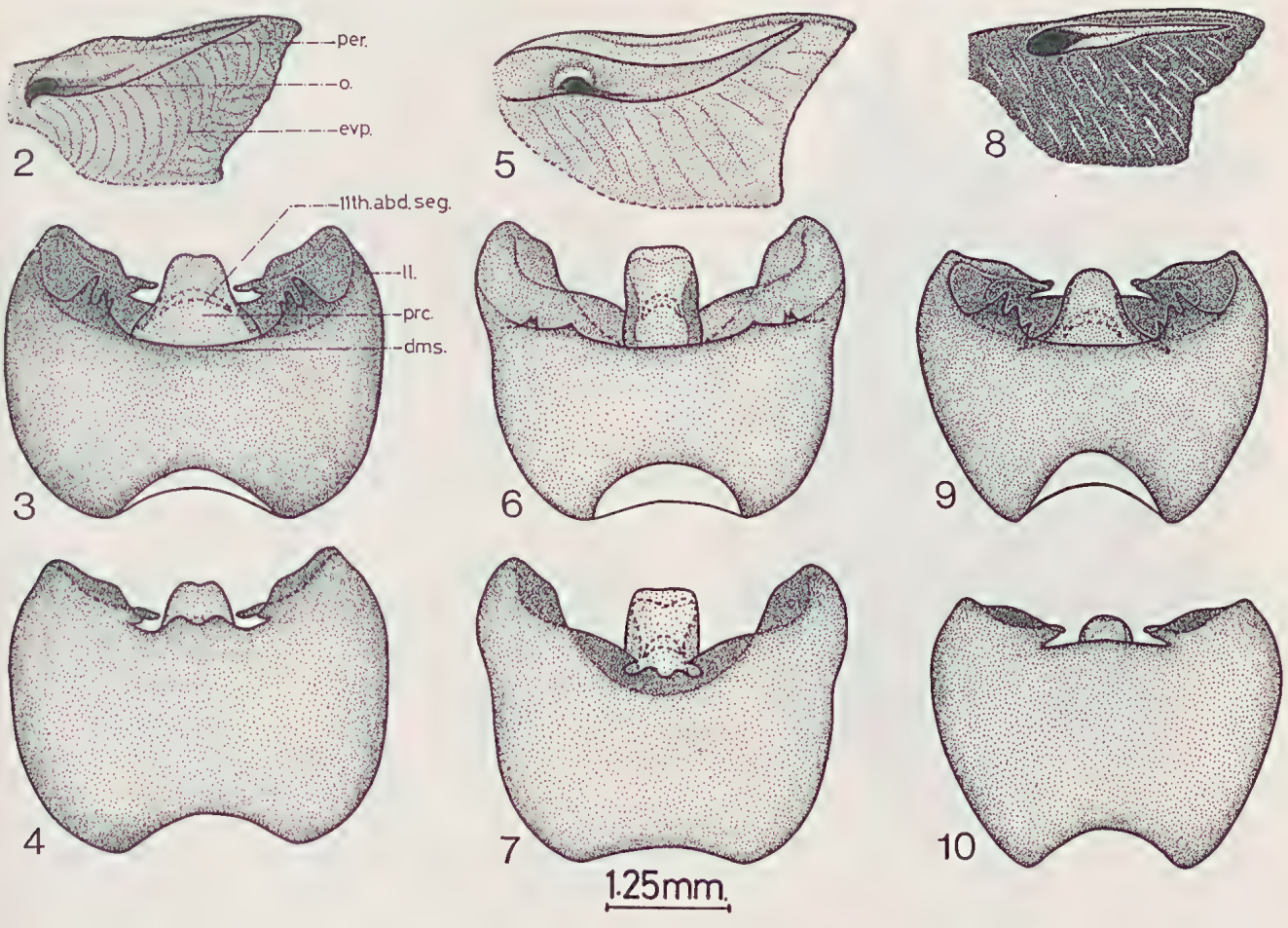
Comparative Note: This species is most closely related to *punctus* (Fabr.) in general appearance but it can easily be separated in having the distal portion of the anterior tibiae dilated, the distal scutellar black patch distally rounded, the ostiolar peritreme much narrower and other characters as noted in the morphological description.

Catacanthus grossi n.sp.

(Figs. 5-7, 11, 16-19)

Coloration: Body coffee-coloured tinged with purple, green and black, except eyes brownish; punctate; ocelli reddish; legs excluding femora, antennae and labium black with greenish tinge, venter and connexiva pale except small portions at connexival joints black, membrane of hemelytra with distal half coffee coloured, proximal half transparent.

Head: Distinctly more than 25% broader than long; anteocular region distinctly shorter than posterior portion of head including eyes; antennae with 3rd segment distinctly longer than 2nd and slightly longer than 2x the basal, length of segments, 1 1.15 mm, 2 2.8 mm, 3 3.25 mm, 4-5 mutilated; labium reaching hind coxae with basal segments shorter than bucculae, 3rd segment distinctly more than 1½x basal, length of segments 1 1.4 mm, 2 1.9 mm, 3 2.3 mm, 4 1.7 mm, labial formula 1<4<2<3; length anteocular region 1.3 mm; length



FIGS. 2-10. 2-4—*Catacanthus carrenoi* Le Guillou, 2—metathoracic scent gland ostiole, evp. (evaporatoria), O. (ostiole), per. (peritreme); 3—pygophore in dorsal view, prc. (proctiger), 11th abd. seg. (eleventh abdominal segment), dms. (dorsomedian surface), ll. (lateral lobe); 4—pygophore in ventral view. 5-7—*Catacanthus grossi* n.sp. 5—metathoracic scent gland ostiole; 6 pygophore in dorsal view. 7—pygophore in ventral view. 8-10—*Catacanthus punctus* (Fabr.). 8—metathoracic scent gland ostiole; 9—pygophore in dorsal view; 10—pygophore in ventral view.

posterior portion of head including eyes 1.6 mm; width 3.8 mm; interocular distance 1.7 mm; interocellar distance 0.8 mm.

Thorax and Abdomen: Pronotum with humeral angles subacute, length of pronotum 4.4 mm, width 10.7 mm; scutellum with apical lobe broad, apex subacute, length of scutellum 9.0 mm, width 6.8 mm; mesosternum slightly carinated and rugulose; metathoracic scent gland ostioles (Fig. 5) small, ovate, peritremes much elongated, medially curved, tapering anteriad, apically acute, evaporating area distinct; distance base scutellum-apex clavus 7.4 mm; apex clavus-apex corium 4.5 mm; apex corium-apex membrane 5.5 mm; apex scutellum-apex membrane including abdomen 8.8 mm; abdomen with basal abdominal spine only reaching mesocoxae; connexiva slightly exposed at repose; female not available. Total length ♂ 25.10 mm.

Male genitalia: Pygophore (Figs. 6 and 7) with dorsomedian surface shallowly concave, one bifurcated, short, spinelike process at inner sides of posterolateral margins, ventroposterior margin pushed in medially, latter raised into bilobed processes following laterally into beaklike structures; parameres (Fig. 16) L-shaped, blade with one short inner process and one dorsolateral out growth, outer margin sinuated, inner margin of anterior half of blade irregular; theca (Figs. 17-19) with an unpaired, dorsal, blunt, thumblike, small median thecal appendage, a pair of dorsal thecal appendages with lateral hornlike semisclerotized lobes, a pair of ventral thecal, proximally semisclerotized and distally sclerotized with larger teeth, a bilobed dorsal membranous conjunctival appendages, distally sclerotized and sinuated, vesica short, penial lobes platelike inner margin straight outer margin sinuated, medially and outwardly fused with conjunctiva.

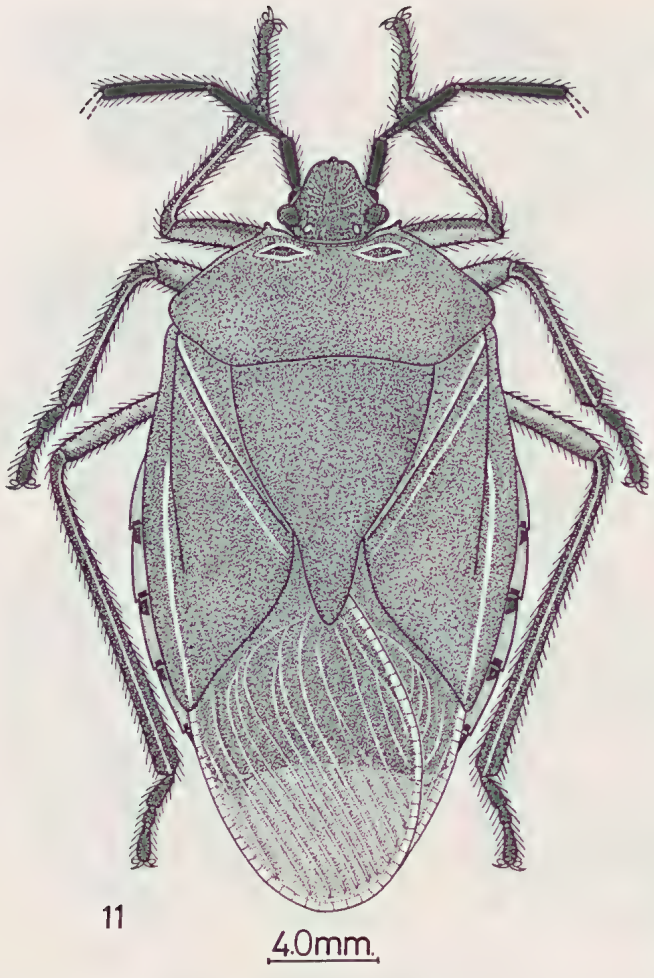


FIG. 11. *Catacanthus grossi* n.sp. in dorsal view.

Material examined: Holotype ♂, at light, vicinity of Anelgahaut, Aneityum I., New Hebrides, July 21, 1971 leg. G. F. Gross, Royal Society-Percy Sladen Trust Expedition (in the South Australian Museum).

Comparative Notes: This new species appears isolated in the entire genus and can be easily separated from the other species in having the chocolate body colour dorsally, elongated medially curved swordlike peritremes and the other characters as listed in the description.

Catacanthus punctus (Fabr.)

(Figs. 8-10, 24-28, 30, 32)

Cimex nigripes Sulzer, 1776, PI. 10 f.9 (*nec* Fabricius)

C. punctum Fabricius, 1787, p. 291.

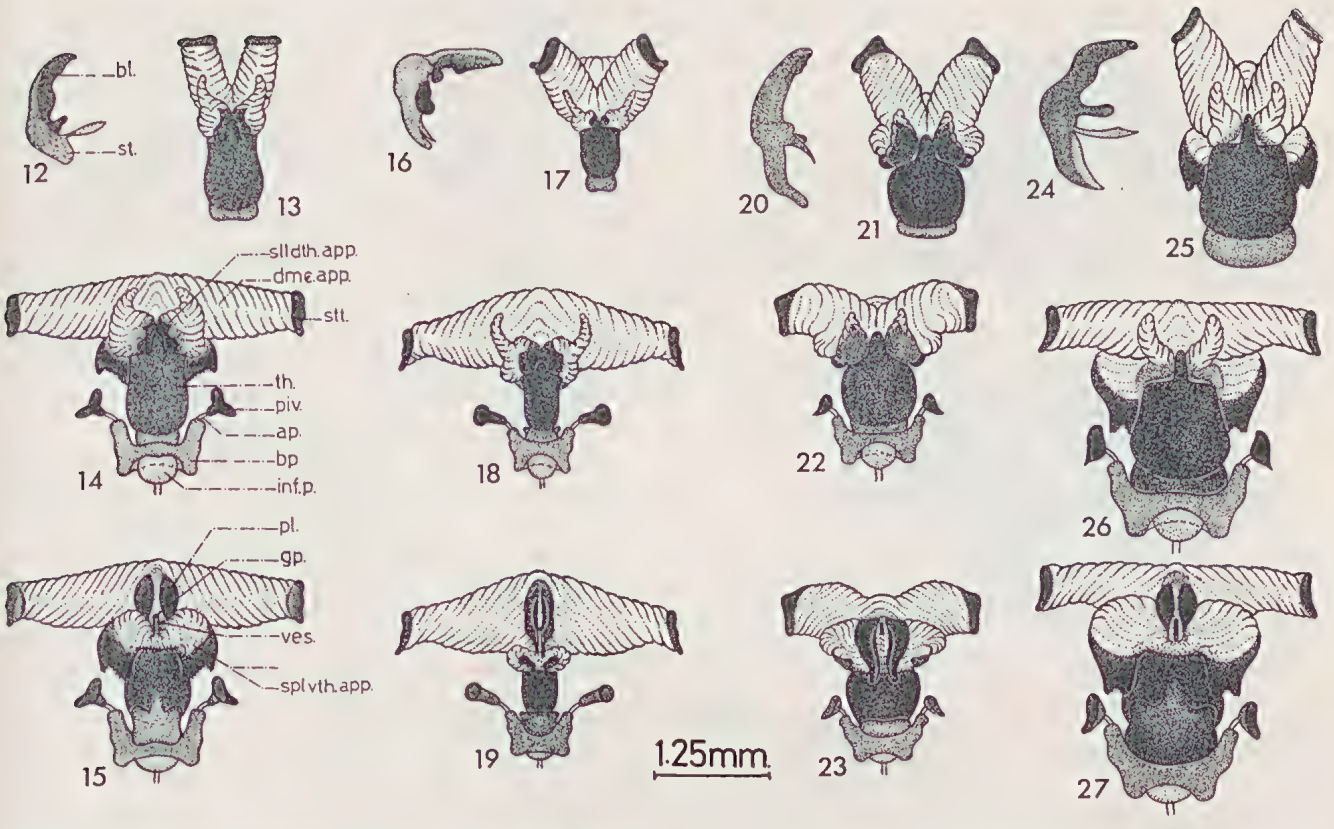
Edessa punctum Fabricius, 1803, p. 149.

Coloration: Body orange, tinged red except head (excluding brownish black eyes), ocelli reddish, pronotum with anterior and anteriolateral margins including callosities and a wide posteriomedial portion, scutellum with basal wide portions, each corium with a large transverse spot on posterior 2/3, clavus with basal portions, legs, antennae and labium black with greenish tinge, connexiva reddish, membrane of hemelytra light brown.

Head: Less than 1/2 again broader than long; anteocular region distinctly shorter than posterior portion of head including eyes; antennae with 3rd segments slightly longer than 2nd and distinctly more than 2¼x basal, length of segments 1 1.3 mm (1.3-1.4 mm), 2 3.0 mm (3.0-3.1 mm), 3 3.25 mm, 4 and 5 mutilated; labium and bucculae as in *carrenoi*, 3rd segment about 1½× basal, length of segments 1 1.5 mm (1.5-1.6 mm), 2 1.9 mm (1.9-2.2 mm), 3 2.2 mm (2.2-2.5 mm), 4 1.7 mm, labial formula 1<4<2<3; length anteocular region 1.4 mm (1.4-1.6 mm); length posterior portion of head including eyes 1.7 mm (1.7-1.8 mm); width 3.6 mm (3.6-3.9 mm); interocular distance 1.7 mm (1.7-1.9 mm); interocellar distance 1.0 mm (1.0-1.1 mm).

Thorax and Abdomen: Pronotum with humeral angles rounded length of Pronotum 4.6 mm (4.6-5.2 mm), width 11.0 mm (11.0-12.8 mm), scutellum with apical lobe narrowed, length of scutellum 9.1 mm (9.1-10.9 mm), width 6.8 mm (6.8-9.0 mm); mesosternum slightly sulcated and rugulose; metathoracic scent gland ostioles (Fig. 8) comparatively large, slitlike, peritremes elongated tapering lateral, apically sharp, acute, evaporative area distinct; distance base scutellum-apex clavus 6.9 mm (6.9-7.8 mm); apex clavus-apex corium 4.3 mm (4.3-5.2 mm); apex corium-apex membrane 6.0 mm (6.0-6.5 mm); apex scutellum-apex membrane including abdomen 8.0 mm (8.0-9.0 mm); abdomen with basal abdominal spine passing mesocoxae; connexiva distinctly exposed at repose; in ♀ posterior margin of 7th abdominal sternum medially deeply folded in, laterally concave. Total length ♂ 24.8 mm, ♀ 28.5 mm.

Male genitalia: Pygophore: (Figs. 9 and 10) with dorsomedian surface concave, three spinelike processes at inner side of posteriolateral margins, ventroposterior margin inpushed medially, latter slightly convex, ventrolateral lobe with two spinelike fused processes, directed inward; parameres (Fig. 24) F-shaped, stem with inner process large, outer and inner margins entire, sinuated, apex narrowed, subacute; theca (Figs. 25-27) with an unpaired, dorsal, blunt, thumblike, comparatively large median thecal appendage, a pair of dorsal thecal appendages with lateral comparatively small hornlike semisclerotized lobes, a pair of ventral thecal proximally semisclerotized and distally sclerotized and comparatively less denticulated and a bilobed dorsal membranous conjunctival appendages, distal portion sclerotized and concave; vesica short, penial lobes ovate medially and outwardly fused with conjunctiva.



FIGS. 12-19. 12-15—*Catacanthus carrenoi* Le Guillou, 12—paramere in inner view, bl. (blade), st. (stem); 12—uninflated theca in dorsal view; 14—inflated theca in dorsal view, ap. (apodeme), bp. (basal plate), dmc. app. (dorsal membranous conjunctival appendage), inf. p. (inflatory pump), slldth. app. (semisclerotized lateral lobe of dorsal thecal appendage), piv. (pivot), stt. (sclerotized tip), th. (theca); 15—inflated theca in ventral view, gp. (gonopore), pl. (penial lobe), splvth. app. (semisclerotized proximal lobe of ventral thecal appendage); 16-19—*Catacanthus grossi* n.sp., 16—paramere in inner view; 17—uninflated theca in dorsal view; 18—inflated theca in dorsal view; 19—inflated theca in ventral view.

FIGS. 20-27. 20-23—*Catacanthus incarnatus* (Drury), 20—paramere in inner view; 21—uninflated theca in dorsal view; 22—uninflated theca in dorsal view; 23—inflated theca in ventral view. 24-27—*Catacanthus punctus* (Fabr.); 24—paramere in inner view; 25—uninflated theca in dorsal view; 26—inflated theca in dorsal view; 27—inflated theca in ventral view.

Female genitalia: (Fig. 31) 8th paratergites fused, medially slightly concave, longer than 1st gonocoxae, latter with posterior margin convex, 9th paratergites lobelike, elongated outer margin sinuated, shorter than posterior margin of fused 8th paratergites, proctiger posteriorly concave, 2nd gonocoxae comparatively narrowed; spermatheca (Fig. 32) with pump region medially swollen, bulb with two unequal elongated fingerlike processes.

Material examined: 2♂, 1♀, Australian but unlocalised (in the South Australian Museum).

Comparative Note: This species is most closely related to *C. carrenoi* as noted above but it can readily be separated in having a smaller body size, the black patch on posterior of pronotum more elongated and a narrowed distal half of the peritremes beside other characters as noted under 'Relationships'.

RELATIONSHIPS OF THE INCLUDED TAXA

Distant (1902, p. 218), although treating *Catacanthus* in his division Nezaria, indicated that further studies might necessitate its separate treatment.

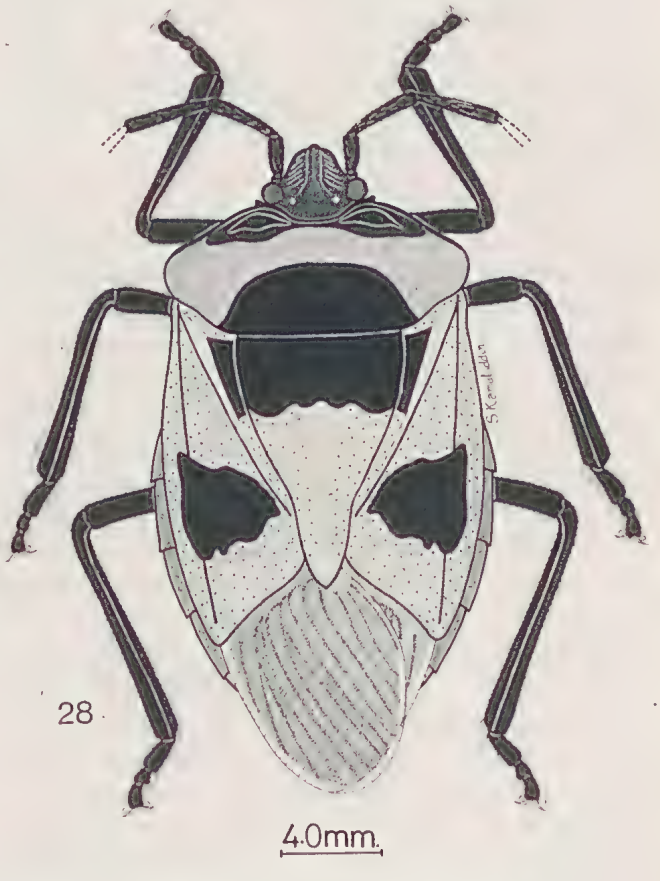
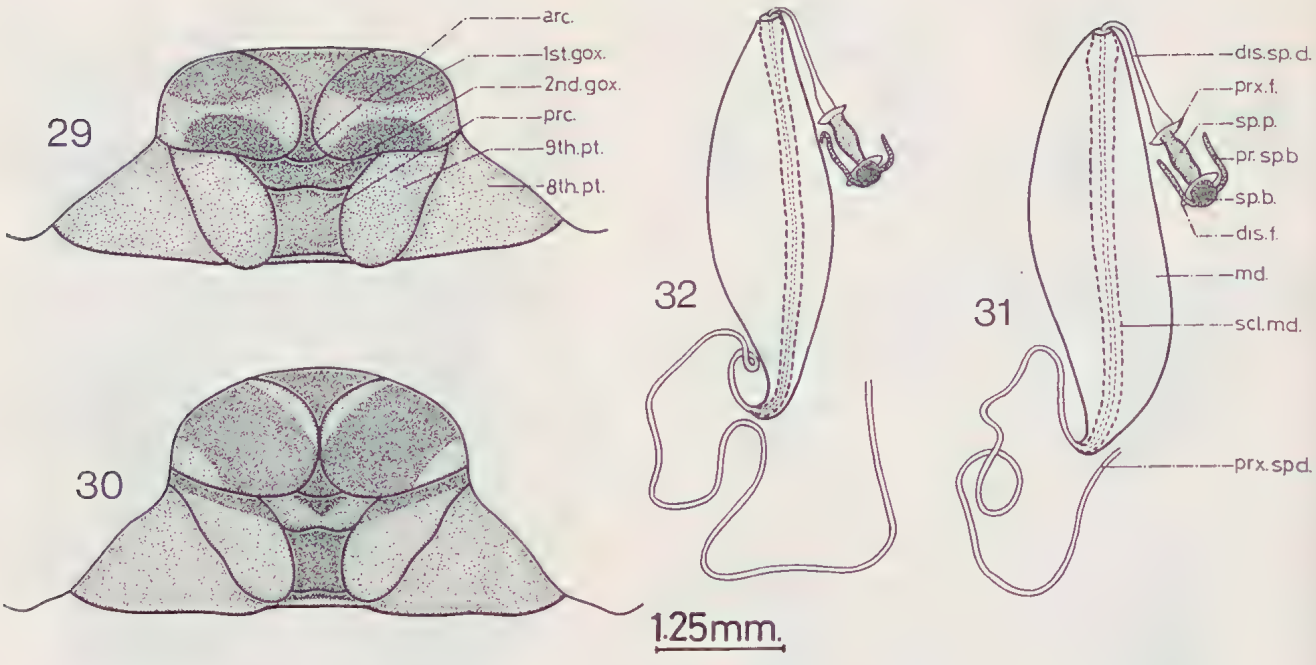


FIG. 28. *Catacanthus punctus* (Fabr.) in dorsal view.



FIGS. 29-32. 29—*Catacanthus carrenoi* Le Guillou—female terminalia in ventral view, 1st. gox. (first gonocoxa), 2nd gox. (second gonocoxa), 8th pt. (eight paratergite), 9th pt. (ninth paratergite), arc. (arcus), prc. (proctiger); 30—*Catacanthus punctus* (Fabr.)—female terminalia in ventral view; 31—*Catacanthus carrenoi* Le Guillou—spermatheca, dis. f. (distal flange), dis.sp.d. (distal spermathecal duct), md. (median dilation), pr.sp.d. (process of spermathecal bulb), prox. f. (proximal flange), prox. sp.d. (proximal spermethecal duct), scl.md. (sclerotized median duct), sp.b. (spermathecal bulb), sp.p. (spermathecal pump); 32—*Catacanthus punctus* (Fabr.)—spermatheca.

Ahmad and Afzal (1978) in their external morphological and internal anatomical studies on *C. incarnatus* (Drury) have clearly demonstrated the distinctness of this genus within the subfamily Pentatominae Amyot et Serville and on that basis have resurrected the tribe Catacanthini Stål to accommodate the genus.

The present Australasian species *C. carrenoi*, *C. grossi* and *C. punctus* are clearly related to the type-species *C. incarnatus* from the Oriental region in their large size (24.8-28.5 mm), reflexed lateral margins of head and pronotum, more prominent clypeus than paraclypei, elongated daggershaped ostiolar peritreme, in male pygophore having dorsolateral inner processes, parameres with more or less prominent inner knobs at the base of the blade (not clearly shown by Ahmad and Afzal 1978), theca with a single dorsomedian, a pair of dorsal thecal appendages (with dorsolateral semisclerotized lobes) and a pair of ventral thecal appendages with ventrolateral semisclerotized lobes, a bilobed dorsal membranous conjunctival appendage with sclerotized tips and penial lobes fused medially and with conjunctiva and in the females with widely exposed arcus and second gonocoxae and spermatheca with a small spherical bulb having a pair of uniformly thin, elongated and curved fingerlike processes. The above characters also isolate *Catacanthus* in the entire subfamily Pentatominae and support Ahmad and Afzal's (1978) resurrection of Stål's tribe Catacanthini as separate from the Pentatomini.

However it shares with other pentatomines the characters of rounded unprojected humeral lobes, moderately narrowed head with sinuated lateral margins, scutellum with a distinct apical lobe, ostiolar peritreme highly developed and base of abdomen always with a spinous projection. Some of the characters of male and female genitalia including the inflated aedeagus with thecal appendages and spherical spermathecal bulb usually bearing fingerlike processes also show the two groups to be closely allied.

C. punctus and *C. carrenoi* appear more closely related to the type species *C. incarnatus* in having a brilliantly coloured and patterned body, a more or less straight ostiolar peritreme, in males the pygophore has the dorsolateral inner processes more or less trilobed, (second and third lobes ill developed in *C. incarnatus*), parameres somewhat F-shaped with a conical inner knob at the base of distally tapering blade, and in other characters as listed under the comparative and morphological notes of *C. carrenoi* and *C. punctus*.

C. carrenoi and *C. punctus* however, appear more closely related to each other in having a shining

black posteriomedian patch on pronotum and a poximal patch on scutellum (Figs. 1 and 28), in male more prominent inner knob of parameres and more or less spinulose comparatively large ventral thecal appendages in the inflated aedeagus (Figs. 15 and 27) and broadly rounded apices of 9th paratergites, in the females (Figs. 29 and 30) in contrast to no patch on pronotum and two shining black lateral patches on proximal portion of scutellum, in males less prominent and very short inner knob of parameres, and smooth comparatively smaller ventral thecal appendages in the inflated aedeagus (Fig. 4, labelled dorsal by Ahmad and Afzal, 1978) and narrowed tapering apices of 9th paratergites in females (Fig. 13, Ahmad and Afzal, 1978) in *C. incarnatus*. The two species have been suggested to be possibly synonymous (Gross, personal communication). However the comparatively much larger spinules on the ventral thecal appendages and the more or less equal processes of spermathecal bulb in *C. carrenoi* together with the other characters listed under the morphological and comparative notes clearly separate it from *C. punctus*.

C. grossi appears on the other hand isolated in the entire genus in having uniformly dark brown body (Fig. 11) with venter and all femora yellow, anterior margin of ostiolar peritreme medially curved (Fig. 5), in males dorsolateral inner processes of pygophore short, bilobed, more or less L-shaped parameres with a large irregular inner knob at the base of more or less uniformly wide blade of parameres and the theca with a less prominent and short dorsomedian thecal appendage (Figs. 17 and 18).

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THE FOSSIL PELICANS OF AUSTRALASIA

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ABSTRACT

RICH, P. V., and van TETS, G. F. 1981. The fossil pelicans of Australasia. *Rec. S. Aust. Mus.* 18 (12): 235-264.

A review of all known Australasian fossil pelecanid material suggests that four species have occurred in the southwest Pacific region during the past 20 million years. The oldest, *Pelecanus tirarensis,* a small robust pelican from Miocene sediments of central Australia, has a distinctive trochlear arrangement of the tarsometatarsus. The younger material is all Pleistocene in age, and most of it can be referred to *P. conspicillatus,* the living Australian Pelican. An exception is *P. novaezealandiae,* originally described as a large New Zealand subspecies of *P. conspicillatus;* it is as different, however, from that species as is *P. onocrotalus. P. cadimurka,* n. sp., is distinctly smaller, being within the size range of *P. tirarensis,* but with a differently shaped tarsometatarsus, more closely resembling that of *P. conspicillatus.*

INTRODUCTION

Pelicans, all in the genus *Pelecanus,* have a long history in Australia, occurring as early as the Miocene in terrestrial deposits of the Lake Eyre Basin, South Australia. Their first occurrence elsewhere in the world is contemporaneous with this antipodean record.

Pelican fossils were first reported from Australia by De Vis (1892) when he recognized *Pelecanus proavus* from Quaternary sediments of south-eastern Queensland. Later he set up an additional two species, *P. validipes* (in Brown, 1894) and *P. grandiceps* (1905). No further pelecanid remains were reported until Miller (1966) reviewed the De Vis material and described a number of new specimens collected during the 1950's on the Stirton expeditions of the University of California and South Australian Museum. Miller set up a new species, *P. tirarensis,* based on a mid-Tertiary fossil from the Lake Eyre Basin and referred all of the De Vis material except the lectotype of *P. grandiceps* and the holotype of *P. validipes* to the living Australian Pelican, *P. conspicillatus.* The same year Scarlett (1966) designated pelican material found in New Zealand as a new sub-species of the Australian pelican, *P.c. novaezealandiae* (see Fig. 1).

Since the mid-1960's more pelican material has been collected. This paper reports on all the fossil pelican material from Australasia. *Pelecanus tirarensis* is quite distinct from all other pelicans, both fossil and Recent. Most of the Quaternary material, however, appears to belong to *P. conspicillatus.* Two forms, one small, *P. cadimurka* n. sp. and one large, *P. novaezealandiae* from New Zealand, appear to be distinct species. The diagnoses of *P. tirarensis* and *P. cadimurka* are based on features of their tarsometatarsi and of *P. novaezealandiae* on features of its synsacrum and femur. We found many elements to be similar in size and shape in several species of *Pelecanus.* The fossil specimens that lacked diagnostic features we have referred therefore tentatively on the bases of size, location and age to: *P. tirarensis,* small, central Australia, Miocene; *P. cadimurka* n. sp., small, central Australia, Quaternary; *P. novaezealandiae,* large New Zealand, Holocene; and *P. conspicillatus,* large, Australia, Quaternary, including the Recent.

ABBREVIATIONS

The following abbreviations have been used in this paper: AM, Australian Museum, Sydney; AMNH, American Museum of Natural History, Ornithology Department, New York; AWMM, Auckland War Memorial Museum, Auckland; CM, Canterbury Museum, Christchurch; ANWC, Australian National Wildlife Collection, CSIRO Division of Wildlife Research, Canberra; NMV, National Museum of Victoria, Department of Ornithology, Melbourne; QM, Queensland Museum, Brisbane; SAM, South Australian Museum, Adelaide; UCMP, University of California, Museum of Paleontology, Berkeley; UCMVZ, University of California, Museum of Vertebrate Zoology; I.Z., Institute of Zoology, Chinese Academy of Sciences, Beijing (Peking). > = greater than, ≯ = slightly greater than, @ = approximately, rf = referred.

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DIAGNOSIS OF ELEMENTS OF *PELECANUS* REPRESENTED BY AUSTRALASIAN FOSSIL MATERIAL

Fossil material discussed below was assigned to the Pelecanidae because of the following combination of characters of these large birds:

Quadrate: Lacks distinct rounded pit for quadrato-jugal; entire ventral articular area with little relief, lacking deep pitting between articular surfaces for mandible and quadrato-jugal such as that present in the Phalacrocoracidae; anterior border of ventral articular surfaces nearly straight lacking any marked process on ventral end that projects medial to mandibular articulation; mandibular articulation parallel-sided over most of medial half; squamosal articulation also of low relief, oriented at 90° to ventral articular surface being compressed mediolaterally; main shaft compressed anterio-posteriorly and lacking pneumatization.

3rd Cervical Vertebra: Prezygapophyses elongate and narrow; diapophyses about one half total length of vertebra with short pleurapophyses extending posteriorly; most dorsally protruding part of neural spine low, and on posterior one-third of vertebra lying posterior to end of parapophyses; diapophyses not bulbous and not extending lateral to prezygapophyses, but continue posterior from them so that vertebra remains nearly same width as anteriormost width to end of pleurapophyses; lateral margins only slightly concave; deep pit on ventral surface near anterior end; prominent bulbous ridge along midline of centrum over posterior half of centrum ends in two prominent blunt projections on either side of midline ridge.

4th Cervical Vertebra: Differs from 3rd only in that dorsal-most expansion of neural spine occurs just slightly posterior to midpoint and at same level as ends of pleurapophyses; ventral pit near anterior end deeper and more elongate; two ventral spines present and very low.

Sternum: (dorso-anterior end only). Lacks dorsal manubrial spine but broad-based ventral spine present, extending anteriorly, not dorsally; coracoidal sulci converge upon one another anteriorly, forming a small obtuse angle; dorsal lips of coracoidal sulci separated and markedly expanded medially, tapering to a fine point posterio-laterally; coracoidal sulci narrow, parallel-sided and deep, being deepest near postero-lateral end; ventral lips of coracoidal sulci straight, not curved or indented.

Scapula: Scapular blade not parallel-sided near proximal end but rapidly narrows distally, becoming parallel-sided near midpoint without any further broadening; near distal end blade narrows to nearly one half of previous width, terminating rapidly in blunt process, not recurved; entire shaft of blade nearly straight, not anteriorly concave; proximal part of shaft quite deep (dorso-ventrally) becoming more flattened distally, with prominent muscle scar on dorsal surface well separated from the proximal end (about one third of the total length of the blade); furcular articulation on elongate process, extending proximally beyond glenoid facet.

Coracoid: Coracoidal fenestra small but complete and well separated from the internal border of the coracoid; scapular facet deeply excavated; glenoid facet not flattened but markedly concave latero-internally; medial and lateral boundaries of shaft nearly straight, not markedly concave or convex, nearly perpendicular to long axis of shaft over medial half and at small obtuse angle over lateral half.

Humerus: Proximal end differs in palmar view from other large birds including storks, cranes, gannets, cormorants, and darters in ligamental groove not extending from ventral edge as far dorsally, and in being a pit rather than a groove. A similar pit occurs also in albatrosses, but the proximal end is more bulbous and rounded in *Pelecanus*, whereas it is thinner and more angular in *Diomedea:* Distal edge, as in waterbirds, orientated at right angles to main axis of shaft and not obliquely with a wide, protruding entepicondyle as in land birds, penguins, and auks. Ectepicondylar spur absent as in most waterbirds except for those in the Procellariiformes and Charadriiformes. As in other Pelecaniformes, distal end curved over more in palmar direction than in other waterbirds. Within *Pelecanus* this is more pronounced than in other

extant genera of the order. The humeri of *Pelecanus* are also decidely larger than those of other extant genera in the order.

Femur: Trochanter low, with both it and head extending an equal distance proximally; trochanter and head not grading smoothly into one another but separated by a distinct, broad channel; head large, about 60 per cent of the length of the trochanter; in lateral view, proximal border of trochanter only slightly, not highly arched with the most proximal extension lying slightly behind anterio-posterior midpoint; no pneumatic foramen present near proximal end on anterior surface.

Tibiotarsus (Distal end only): Internal condyle extends far distad of external and is much more elongate than internal; single supratendinal bridge lacks any ligamental prominences on either medial or lateral ends and forms small acute angle with long axis of shaft; shaft lacks external flange just proximal to external condyle; in distal view, condyles deep, with internal slightly deeper than external; distal end slightly broader anteriorly than posteriorly but lacking any marked constriction near anteroposterior midpoint.

Tarsometatarsus (Distal end only): Trochlea II longer (extending further distally) than trochlea IV; in medial view, trochlea II not extending far posteriorly and lacking medial spike on posteriomedial border; trochlea II lacking medial groove extending over entire trochlea but notched distally and posteriorly; in distal view, medio-lateral axis through trochlea II-IV not straight but arched.

SYSTEMATIC POSITIONS OF AUSTRALASIAN FOSSIL MATERIAL

Australasian fossils referred to *Pelecanus* by De Vis (1892, 1905; in Brown, 1894), Archey (1931), Miller (1966), and Scarlett (1966) are summarized with our determinations in Table 1 and on Figure 1. We have re-examined most of this material and have added to it a number of new specimens collected over the past decade and a half.

Pelecanus tirarensis

Citation: Miller, A. H., 1966. Mem. Queensland Museum, 14 (5), 182, Fig. la, c, e.

Holotype: Distal end, right tarsometatarsus SAM P13858.

Locality and Age: Lake Palankarinna Site 3, Turtle Quarry (UCMP V-5762), west side of lake, South Australia, Etadunna Formation, Miocene. 28°48′S, 138°24′E.

Comment: The holotype of *P. tirarensis* (SAM P13858) differs from the tarsometatarsi of living pelicans (see Figure 2 and Tables 2, 3 and 4) in having:

(1) an elongate trough developed on the posterior margin of the medial surface of trochlea II, separated from the ligamental pit by a slender ridge that is orientated nearly due proximo-distally along trochlea; this ridge trends posteriorly towards distal end and broadens slightly; in all other species examined this area is occupied by an elevated, inflated ridge that continues all the way to the posterior border of the trochlea, when trochlea II viewed posteriorly; the presence of the trough in *P. tirarensis* produces a more gracile trochlea over much of its length, as pointed out by Miller (1966);

(2) a decidely narrower anterior margin of trochlea II than posterior margin (in distal view) rather than both approaching the same width. Differs from *P. occidentalis* and *P. erythrorhynchos* in having a trochlea II that extends much further distally than trochlea IV; in *P. occidentalis* and *P. erythrorhynchos* trochlea II extends only slightly distad of trochlea IV; *P. conspicillatus* and *P. onocrotalus* have trochlear conditions very similar to those in *P. tirarensis*.

Miller (1966) noted also that the size of the ligamental pit on trochlea II is greater than that on other pelicans; in our sample of *P. conspicillatus* this character seems too variable to be of diagnostic value, and our largest specimen (ANWC BS1202) had a large ligamental pit approaching that of *P. tirarensis*. Miller further noted that the distal foramen was less elongate on the plantar surface than that in *P. conspicillatus;* examination of our sample of *P. conspicillatus* (n=20) bore this out, but in the sample of *P. erythrorhynchos* (n=5) the character varied from the condition in *P. conspicillatus* to that in *P. tirarensis; P. onocrotalus* and *P. occidentalis* have distal foramina as in *P. tirarensis*. From fragments of SAM P13858 available, we cannot verify the position of the origin of the plantar ridge on the posterior surface nor can we see this in Miller's illustrations. Thus, comparison of proportions of the shaft (length vs. width) based on the location of this feature seems impractical.

Referred Material: UCMP 60988: Distal end, right tarsometatarsus, Lake Palankarinna, Site 6, UCMP V-5765, 28°46′S, 138°25′E, South Australia, Etadunna Formation, Miocene.

Comment: UCMP 60988 is very incomplete, lacking trochlea II and with articular surfaces of trochlea III and IV very worn so that the original surface cannot be defined on trochlea IV (see Figure 3). Thus, the diagnostic characters defining *P. tirarensis* cannot be evaluated sufficiently even though the distal foramen is small and ovoid, as in *P. tirarensis*, and the size is comparable (see Tables 2

and 3). We have therefore only tentatively referred it to this species.

UCMP 113115: Distal end, right tarsometatarsus, lacking distal end of trochlea II and totally lacking trochlea IV, Leaf Locality, UCMP V-6213 Lake Ngapakaldi, 28°18′S, 138°16′E, South Australia, Wipajiri Formation, late Miocene.

Comment: UCMP 113115 lacks those areas exhibiting characters diagnostic of *P. tirarensis*. Its size is comparable to that species (see Figure 3 and Table 3) and its distal foramen is of moderate size. We therefore only tentatively refer it to *P. tirarensis*.

AMNH 11494: Proximal end of right tarsometatarsus, lacking much of hypotarsus, Lake Pinpa, 31°08′S, 140°12′E, southeast of Lake Frome, Tarkarooloo Basin, South Australia, Namba Formation, Miocene.

Comment: AMNH 11494 is definitely pelecanid in that the proximal articular surfaces are deep; the intercotylar prominence is very prominent and is restricted to the anterior part of the proximal end; the hypotarsus viewed posteriorly, is triangular in shape with the longest portion on the internal side; there are two well defined calcaneal canals; the anterior surface of the shaft near the proximal end is deeply excavated with two large vascular foramina in this deep excavation. AMNH 11494 is smaller than the tarsometatarsi of *Pelecanus conspicillatus*, and differs further in that the lateral calcaneal notch is only slightly indicated and not deeply incised; the anterior border of the lateral articular surface does not form a sharp apex, but is rounded; the whole lateral articular surface is relatively broader; viewed anteriorly, the external foramen is smaller and not as enlarged as the internal foramen; the excavation of the anterior surface at the proximal end and further distad is relatively deeper; the tubercle for *tibialis anticus* is displaced onto the medial surface of the excavated area on the anterior surface rather than being more or less centrally located; the foramina on either side of the hypotarsus are relatively smaller than in *P. conspicillatus*.

Because AMNH 11494 is badly eroded, only the following measurements were practical: width across proximal end @ 18 mm; and depth across lateral articular surface and lateral calcaneal ridge of hypotarsus @ 14 mm. In *P. conspicillatus* these parameters are width: n = 10, range 22-24 mm, mean 23 mm, s.d. 1 mm; and depth n = 10, range 17-20 mm, mean 18 mm, s.d. 1 mm. Because of its size and age we refer AMNH 11494 tentatively to *P. tirarensis*.

QM F10703: Distal end of left tarsometatarsus, Crocpot 1, south end of Lake Palankarina, 28°46′S, 138°28′E, South Australia, Etadunna Formation, Miocene.

Comment: QM F10703 fits within the above description of the holotype, except that the proximodistal ridge does not broaden towards the distal end; we, therefore, refer it to *P. tirarensis*.

Pelecanus proavus

Citation:
De Vis, 1892. Proc. Linn. Soc. New South Wales, 2(6): 444 Pl.24.

Holotype: No number (type lost), left tarsometatarsus.

Locality and Age: Darling Downs, 28°S, 150°E, Queensland, Quaternary.

Comment: *Tarsometatarsus.* Miller (1966) re-evaluated this left tarsometatarsus and assigned it to *P. conspicillatus;* the illustrations provided by De Vis (1892) are not helpful in making this assignment. Based on the illustrations, it appears that the distal foramen in *Pelecanus proavus* is not rounded, but is not as elongate as those in our sample of *P. conspicillatus*, being more like that in *P. onocrotalus*. This may be due to inaccurate illustration of damage to trochleae, which De Vis (1892) mentions.

De Vis' illustrations also indicates that there is little flare of the distal end of the tarsometatarsus of *P. proavus*, which most closely approaches the condition in *P. onocrotalus*. In most *P. conspicillatus*, *P. erythrorhynchos*, and *P. occidentalis* this flare, particularly on the internal margin of the shaft, is more pronounced.

The measurements made from De Vis' illustrations of the holotype suggest a medium-sized pelican, such as *P. rufescens* and *P. philippensis*. However, we are not entirely convinced that De Vis' illustrations are accurate because of the discrepancy between his measurement of the trochlear expansion and ours of the distal width of the illustration of the fossil, both of which appear to be the same measurement. De Vis (1892) originally recorded the 'width of the trochlear expansion' as 16.5 mm, but our measurements of maximum width of the distal end made from Figures 6a, 6b, Plate 24 were 18.0-18.6 mm (see Table 2).

Thus, at present until the original specimen is available we reserve judgment on the validity of *P. proavus*.

Carpometacarpus: De Vis (1892) assigned a proximal carpometacarpal fragment, QM F1141, to *P. proavus*, but we concur with Miller (1966) that it is not pelecanid.

Femur: De Vis (1905) assigned a distal right femur fragment (QM F3752, Lower Cooper Creek, South

Australia, Quaternary) to *P. proavus*. When we compared it with femora of large pelicans, *P. conspicillatus* and *P. onocrotalus*, we could find no appreciable differences (see Figure 4 and Table 5).

De Vis (1905) mentions that the fibular groove is more extensive in *P. proavus*, covering most of the fibular condyle and making it concave posteriorly further distad than in *P. conspicillatus*. Additionally, the ectepicondylar region in the extinct bird was supposedly comparatively narrow and rather deeply sunken between the trochlea and the ectepicondylar edge, the cavity formed extending distad nearly two-thirds of the length of the trochlea (De Vis, 1905: 17). These characters are so similar in some specimens of the modern Australian Pelican that this fossil is best referred to *P. conspicillatus*.

Tibiotarsus: De Vis (1905) assigned the distal end of a right tibiotarsus (QM F3753, Lower Cooper Creek, South Australia, Quaternary), damaged on the internal condyle, to *P. proavus*, noting that there was nothing to distinguish it from the extinct form. Our comparisons with other large pelicans including *P. conspicillatus*, have revealed no diagnostic characters that set his fossil tibiotarsus apart (see Figure 4 and Table 6), and thus it should be referred to *P. conspicillatus* as Miller (1966) suggested.

Pelecanus conspicillatus

Citation

Pelecanus conspicillatus Temminck, 1824 Planches col.Oiseaux 47: pl.276.

New Synonymy of Fossil Forms

Pelecanus validipes. De Vis, 1894 (in Brown, Proc. Parl. So. Aust., 2(25): 21, pl. 11, 5-6).

Archaeocycnus lacustris (in part) De Vis, 1905 (Ann. Qld. Mus., 6:13).

Pelecanus grandiceps. De Vis, 1905 (Ann. Qld. Mus., 6: 16, Pl. V, Figs. 1-3).

Fossil Material Described by De Vis

Pelecanus validipes

Holotype: Distal end of a right tarsometatarsus, SAM 18412, Warburton River, South Australia, Quaternary.

Comment: Contrary to the comments made by De Vis (in Brown, 1894) we have found that (see Fig. 2):

(1) the middle trochlea (III) is not broader than that in *P. conspicillatus;*

(2) the hallucal depression is no better defined (in fact ANWC BS1363, *P. conspicillatus*, matches the condition in *P. validipes*);

(3) the dorsal sulcus is not any deeper nor the bounding ridges more well defined than in *P. conspicillatus;*

(4) the distal end of the plantar ridge is no straighter than in some *P. conspicillatus;* and

(5) *P. validipes* is within the size range of the living *P. conspicillatus* that we have measured (see Tables 2, 3 and 4).

Thus, we suggest that *Pelecanus validipes* be synonymized with *P. conspicillatus*.

Archaeocycnus lacustris (in part)

Relevant Syntype: Fragment of 4th cervical vertebra (QM F5529), unknown locality.

Comment: Among a series of bones that De Vis (1905) named *Archaeocycnus lacustris*, a new genus and species of swan, was a cervical vertebra that is not anatid, but pelecanid (see Fig. 3). The vertebra is quite eroded anteriorly and dorsally and thus preserves few useful characters. It is, however, of a pelican within the size range of *P. conspicillatus* (see Table 7) to which species it should be referred and removed from the Anatidae and the syntypes of *Archaeocycnus lacustris*.

Pelecanus grandiceps

Lectotype: Miller, 1966: QM F3751, left distal end of a tarsometatarsus, Lower Cooper Creek, South Australia Quaternary.

Comment: Miller (1966) in his review of Australian pelicans chose to retain this species as distinct from the extant Australian pelican, *P. conspicillatus* because of the following features of the lectotype tarsometatarsus: (1) large size; (2) 'presence of a deep pit on the plantar surface between the bases of trochleae III and II' (Miller 1966: 187); and (3) 'a greater breadth and flattening of the trochlear ridges on the anterior surface (of trochlear III)' (Miller 1966: 187).

QM F3751 (see Fig. 2 and Tables 3 and 4) only slightly exceeds in size the tarsometatarsi of *P. conspicillatus* in only one out of four measurements that are practical on the fossil. We doubt that this difference is significant. The deep pit on the plantar surface between the bases of trochleae II and III, present on QM F3751 is represented by only a tiny foramen on a specimen that Miller (1966) referred to this species (UCMP 56322, Lower Cooper Creek site 8, UCMP V-5860, South Australia, Quaternary) (see Fig. 3 and Table 4). In our sample of recent *P. conspicillatus* one specimen (ANWC BS1272) exhibited a distinct pit on the right tarsometatarsus and a pinhole foramen on the left tarsometatarsus. Thus, this character seems quite variable between and even within individuals and not particularly useful taxonomically for the genus

Pelecanus. The anterior ridges on trochlea III increase in breadth and flattening with size, and our largest specimens of *P. conspicillatus* approach or match that of *P. grandiceps*.

Thus, we suggest that *Pelecanus grandiceps* be synonymized with *P. conspicillatus*.

Quadrate: De Vis (1905) named a fragmentary left quadrate (QM F3749, Lower Cooper Creek, South Australia, Quaternary), *P. grandiceps*, because of qualitative differences as well as a distinctly larger size than *P. conspicillatus*. We agree with Miller (1966) that, in fact, this specimen is within the range of variability of the living *P. conspicillatus* (see Fig. 3 and Table 8), and we therefore refer it to this species.

Coracoid: De Vis (1905) assigned to *P. grandiceps* a left coracoid (QM F3750, Lower Cooper Creek, South Australia, Quaternary), lacking both dorsal and ventral ends but including most of the glenoid facet and part of the scapular facet. Although not preserving much that is diagnostic, the position of the coracoidal fenestra in the fossil form more closely approaches that in *P. onocrotalus*, where the coracoidal fenestra is displaced further laterad from the medial margin and thus is positioned nearer the centre of the coracoidal shaft than in most of our sample of *P. conspicillatus*. Because of the lack of a more complete bone, it is difficult to interpret the significance of this character, and because it is similar in size to those of modern *P. conspicillatus* (see Fig. 4 and Table 9) we refer it to this species as suggested by Miller (1966).

In conclusion, we can see no valid reasons for maintaining *Pelecanus grandiceps* as a species distinct from *P. conspicillatus*.

Additional Material

Quadrate: UCMP 56321, left, Cooper Creek, Site 8, UCMP V-5860, 28°34′S 138°00′E, South Australia, Quaternary. Left quadrate nearly complete except for erosion along some articular surfaces. Together with those of other living species of pelicans, this specimen differs from that of *P. occidentalis* in that the pneumatic foramen lies on internal rather than external surfaces; the otic process is short rather than elongate giving the quadrate a remarkably different shape. Allowing for variability in modern populations of pelicans, only the much larger *P. onocrotalus* can be ruled out. The fossil quadrate is similar in size to quadrates of several living species, including *P. conspicillatus*, and thus we follow Miller (1966) in referring it to this species (see Fig. 3 and Table 8).

Palatines: UCMP 60702, fused palatines, Cooper Creek, Malkuni Waterhole 28°34′S 138°09′E, South Australia, UCMP V-5382, Quaternary. We follow Miller (1966) in referring this specimen to *P. conspicillatus*.

Vertebrae: UCMP 56394, posterior half of 3rd cervical vertebra, Cooper Creek, Site 7, 28°33′S 138°10′E UCMP V-5859, South Australia, Quaternary. Miller (1966) assigned this specimen to *P. conspicillatus*. In size it matches measurements of several of the larger pelicans (see Fig. 3 and Tables 10 and 11), and we can find no diagnostic differences from any of these forms, including *P. conspicillatus*. Thus we refer it to this species.

Sternum: UCMP 60656, anterior fragment of sternum, Cooper Creek, Site 18, 28°35′S 138°08′E, UCMP V-6147, South Australia, Quaternary. Although larger than any of our sample of *P. occidentalis*, this specimen falls again in the range of the larger pelicans, except for perhaps *P. onocrotalus* (see Fig. 3 and Table 12), and is so fragmentary that definite assignment to any species is rather senseless. We follow Miller (1966) in referring it to *P. conspicillatus*.

Coracoid: QM F6669, fragment of a left coracoid, Lower Cooper Creek, South Australia, Quaternary. Although part of a collection made during the summer of 1901/2 by J. W. Gregory and his students during the Melbourne University Lake Eyre Expedition, we are not aware that De Vis and Miller have commented on this specimen in print. We refer QM F6669 (see Table 9) to *P. conspicillatus* as it is within the size range of this species and we can discern no qualitative differences.

UCMP 60487, fragment of a left coracoid, Cooper Creek, Site 8, UCMP V-5860, Quaternary. We refer this specimen to *P. conspicillatus* in agreement with Miller (1966).

Ulna: UCMP 56348, distal end of left ulna, Cooper Creek, Site 16, UCMP V-5868, South Australia, Quaternary. UCMP 60520, distal end of left ulna whose articular surfaces are eroded, Cooper Creek, Site 8, UCMP V-5860, South Australia, Quaternary. We agree with Miller (1966) in referring these specimens to *P. conspicillatus* (see Fig. 2 and Table 13).

Cuneiform: UCMP 60503, left cuneiform, Cooper Creek, Site 8, UCMP V-5860, South Australia, Quaternary; UCMP 60549, right cuneiform, Lake Kanunka, Site 2, UCMP V-5773, 28°23′S, 138°17′E, South Australia Katipiri Sands, Quaternary. We agree with Miller (1966) in referring these specimens to *P. conspicillatus* (see Fig. 2 and Table 14).

Femur: UCMP 604777, proximal fragment of right femur, Cooper Creek, Site 8, UCMP V-5860, South Australia, Quaternary. Miller (1966) assigned this specimen to *P. conspicillatus* but because of the lack of any diagnostic differences either in morphology or

size with most other large pelicans (see Fig. 4 and Table 15), we can only refer it to this species. *P. rufescens* and *P. occidentalis* appear to be distinctly smaller, and *P. crispus* (based on one specimen) has a flattened, not curved, trochanter (viewed laterally), which does not slope anteriorwards as it does in UCMP 60477.

Tibiotarsus: UCMP 60521, very fragmentary, Distal right, tibiotarsus, Cooper Creek, Site 8, UCMP V-5860, South Australia, Quaternary. Because of the incompleteness of this specimen, little can be said of its affinities except to the family Pelecanidae. It falls within the size range of *P. conspicillatus* and several other large pelicans (see Fig. 4 and Table 6). Therefore, we refer it tentatively to *P. conspicillatus.*

Humerus: UCMP 60640, very fragmentary distal left humerus with only external and internal condyles and external margin preserved, Cooper Creek, Site 18, UCMP V-6147, South Australia, Quaternary. Miller (1966) placed it in *P. conspicillatus.* In size and shape it is similar to the humeri of *P. conspicillatus* and other large species of pelican (see Fig. 3 and Table 16). We therefore tentatively refer UCMP 60640 to *P. conspicillatus.*

Scapula: UCMP 56633, right scapula missing parts of the glenoid facet and furcular articulation, Warburton River, Marcus Locality, 27°55′S, 138°00′E, UCMP V-5569, South Australia, Quaternary. The distance between the furcular facets is very narrow, but this character is extremely variable even within *P. conspicillatus.* The angle at which the two furcular facets meet (in ventral view) is slightly greater than 90°, but this varies from an acute to slightly obtuse in *P. conspicillatus.* In our small samples it is slightly obtuse in *P. occidentalis* and *P. onocrotalus* and acute in *P. erythrorhynchos.* In size UCMP 56633 is similar to the scapulae of the larger species of pelican (see Fig. 3 and Table 17), and we therefore tentatively refer it to *P. conspicillatus.*

Pelecanus novaezealandiae

Citation: *Pelecanus conspicillatus novaezealandiae.* Scarlett, 1966, Notornis 13: 204, Fig. 1 1-11.

Holotype: Large part of a single skeleton including mandibular fragments, left quadrate, pelvis, right and left humerus, right ulna, right and left radii, right and left carpometacarpi, left scapula, right and left coracoids, right and left femora, right tibiotarsus, right and left fibulae, right and left tarsometatarsi, and several vetebrae, CM AV21355.

Locality and Age: Poukawa, Site I, Hawkes Bay, New Zealand, (39°45′S, 176°43′E) Quaternary, between 3500 and 4500 years B.P. The holotype was found just below the Waimihia Ash, a band of airfall volcanic ash, that was deposited 3440 ± 70 years B.P. (pers. comm. P. Horn 1979).

Diagnosis: Very large pelican. Differs from recent large pelicans in that its pelvis is distinctly broader and more robust (see Fig. 5 and Tables 2-6, 9, 13, 15-19) particularly across supratrochanteric processes; ilioischiatic foramen not extremely elongate, thus differing from *P. conspicillatus* and more resembling *P. onocrotalus;* proximal end of femur wider than largest of *Pelecanus,* although most other measurements overlap. Tarsometatarsus longer than femur as in *P. conspicillatus* and not shorter as in *P. onocrotalus.*

Referred Material: Partial skeleton (no number, now lost), Archey (1931), cave deposits near Lake Waikaremoana, North Island (38°47′S, 117°06′E); right coracoid (CM AV15089), right humerus (CM AV12264), left femur (CM AV12482) and proximal end, right humerus (CM AV13095), Marfell Beach, Lake Grassmere, South Island (41°42′S, 174°10′E); distal left tibiotarsus (AWMM AU5845.1), Puheke Beach, Karikari Peninsula, North Island (34°55′S, 173°22′E); left tibiotarsus and fragments of a left ulna (private collection of Peter Horn), type locality Poukawa, Site N141/1; part of fused furcula and sternal keel (CM AV32001) type locality, Poukawa; all Holocene in age.

Comment: Scarlett (1966) noted most of the characters we have utilized to define the species, *Pelecanus novaezealandiae.* Because his sample of modern pelicans was so small, he chose to recognise the New Zealand form as only a separate subspecies. With our additional samples, we believe that the New Zealand form is sufficiently distinct, especially in the robustness of the pelvis and proximal hind limb, that it rates separation as a species.

Pelecanus cadimurka n. sp.

Holotype: SAM P22501, left tarsometatarsus fragment lacking trochlea IV and with some erosion of posterior border of trochlea II (see Fig. 6).

Locality and Age: Kuttipirra (Katipiri) Waterhole, Cooper Creek Site 9, UCMP V-5861, 28°33′S, 138°06′E, South Australia, Quaternary.

Etymology: Cadimurka (Aboriginal), noun in apposition. Brown (1894:5) in reporting the presence of bones of extinct animals at several places along the Warburton River, mainly along the edges of large waterholes, writes that 'The natives account for the presence of these bones by saying that they belong to the cadimurka, a large fish which lives in the bottom of the waterholes, and which has consequently never been seen by them'. One of the bones picked up by Brown on the Warburton River

is the holotype of *Pelecanus validipes*, and the material of *P. cadimurka* has been subsequently found in the same area.

Diagnosis: Small pelican in the size range of *P. occidentalis* and *P. rufescens*, distinctly smaller than *P. conspicillatus* and all other living species of pelican (see Fig. 2, 6 and 7 and Tables 2, 3 and 4). Where comparable published fossil material exists, only *P. tirarensis* and *P. gracilis* are of similar size. In medial view trochlea II lacks a deep channel on posterior border of medial surface, thus differing from *P. tirarensis*. Trochlea II and III extend an equal distance distally, unlike in most other pelicans, including *P. occidentalis* and *P. conspicillatus* where III is distinctly longer. In distal view, trochlea II is relatively narrow with posterior and anterior borders of nearly equal width, differing from (1) *P. conspicillatus*, which tends to be broader overall and laterally expanded along the posterior border, (2) *P. tirarensis* where the anterior border is decidedly narrower than the posterior, and (3) *P. occidentalis*, which tends to be broader. Trochlea III is deep and not shallow as in *P. occidentalis*, thus more closely approaching the condition in *P. conspicillatus*. Trochlea III is relatively slender, and not as broad as in *P. tirarensis* (see Fig. 2). In posterior view, articular surface of trochlea II terminates in a distinct apex proximally and is not squared off as in *P. occidentalis*. The shape of the distal foramen is not long and slit-like as in *P. conspicillatus* but more closely approximates those of *P. onocrotalus* and *P. occidentalis*.

Referred Material: UCMP 60577-60578. Two distal fragments of right tarsometatarsi with all three trochlea represented, Lake Kanunka, Site 2, UCMP V-5773, 28°23'S, 138°17'E, South Australia, Quaternary. Both specimens are slightly smaller than any of our samples of *Pelecanus conspicillatus*, about the size of *P. tirarensis* (See Fig. 3 and Tables 2, 3 and 4). On trochlea II, the posterior channel that characterizes *P. tirarensis* is not present, thus eliminating this species. In UCMP 60578 there is a small posterior depression in this area, but this condition can be matched in our sample of *P. conspicillatus*. The distal foramen is intermediate in shape between those of *P. conspicillatus* and *P. tirarensis*, more like those of *P. onocrotalus* and *P. erythrorhynchos*, but this character may quite likely vary somewhat with broader sampling. The trochleae of UCMP 60577 do not appear to flare as broadly distally as they do in *P. conspicillatus* and *P. tirarensis*, more closely approaching the condition in *P. onocrotalus*. Because parts of UCMP 60577 have been eroded, however, a final evaluation of this character is advisable. In both specimens, trochlea II extends far distad of trochlea IV as in other large pelicans including *P. tirarensis*, distinguishing it from *P. occidentalis* and *P. erythrorhynchos*.

Comment: Although these two specimens are somewhat intermediate is size between the holotype of *P. cadimurka* and the tarsometatarsi of *P. conspicillatus*, they appear to be qualitatively distinct from the latter as well as those of *P. tirarensis* and *P. occidentalis*. The specimens compare well with the holotype of *P. cadimurka* and thus will be referred to that new species. Miller (1966) had previously assigned both the above specimens to *P. conspicillatus*.

Our measurements from the De Vis figures of the holotype tarsometatarsus of *P. proavus* are within the ranges of those of the *P. cadimurka* material but because of a discrepancy between De Vis' and our measurements (see above) we doubt the scale of his figures and do not feel justified in referring the material of *P. cadimurka* to *P. proavus*. Furthermore, trochlea III is figured substantially longer than trochlea II in *P. proavus* and thus differs from the holotype of *P. cadimurka*.

UCMP 123382: Nearly complete 4th cervical vertebra, Cooper Creek, Site 8, V-5860, South Australia, Quaternary.

Comment: The vertebra is much smaller than any of *P. conspicillatus* in our sample (see Table 7) although very similar in shape. Also it is more gracile than those of *P. occidentalis*, which are anterio-posteriorly compressed and more robust. It differs further from those of *P. occidentalis*, and is similar to those of *P. conspicillatus*, in lacking paired ridges over posterior half of ventral surface and in having a decidedly shallower pit just posterior to anterior articular surface of centrum on ventral surface. The vertebra may be, relative to total length, slightly broader across ventral surface of centrum on posterior half than in *P. conspicillatus*. It appears that this represents a species of pelican smaller than the extant and the Quaternary *P. conspicillatus*, and we have therefore referred it to *P. cadimurka*.

Not Pelecanidae: UCMP 69587. Proximal end, right humerus, Lake Kanunka, UCMP V-5773, South Australia, Quaternary.

Comment: Miller (1966) assigned this specimen to *P. conspicillatus*. Upon re-examination we find that the humerus is certainly within the size range of some living pelicans, but it shows considerable morphologic differences from all Pelecanidae. In UCMP 69587 the ligamental furrow is deeper. The bicipital furrow is deeply excavated instead of flat. In proximal view, the head narrows considerably near the external tuberosity, and is not bulbous.

In all of these characters, the fossil so closely resembles members of the Accipitridae that it should be transferred to this family. It appears to represent a giant raptor, larger than the living Wedge-tailed

Eagle, *Aquila audax* and more similar in size to the extinct New Zealand Eagle, *Harpagornis moorei.*

COMPARISON OF AUSTRALIAN FORMS WITH OTHER FOSSIL PELICANS

Brodkorb (1963) lists eight fossil species of pelicans, and recently Harrison and Walker (1976) have reported a ninth, *Pelecanus aethiopicus* from East Africa. Many of these are not directly comparable with most of the Australasian material except *P. novaezealandiae. P. intermedius* and *P. fraasi,* both from the Miocene of Europe, are known only from cranial material; *P. halieus* from the early Pleistocene of North America, a radius representing a bird the size of *P. erythrorhynchos; Liptornis hesternus* from the Miocene of Argentina, a lower cervical vertebra, whereas the Australian material is represented by higher cervicals.

P. aethiopicus from the Middle Pleistocene of East Africa is not directly comparable to Australian fossils as it is represented only by a proximal end of a tarsometatarsus and a scapula; scapulae of both *P. aethiopicus* and one Australian Pleistocene fossil pelican are so worn and broken that qualitative comparisons are futile, although they are clearly within the same size range.

The remaining fossil pelicans are at least represented by materials comparable to Australian specimens. *P. gracilis* (proximal humerus, femur, scapula, partial tarsometatarsus); *P. cautleyi,* (distal ulna); *P. sivalensis,* (distal ulna); and *P. odessanus* (coracoid, tarsometatarsus).

As Miller (1966) pointed out, *P. gracilis* from the early Miocene (Aquitanian) of Europe is decidedly smaller and more slender-legged than *P. conspicillatus.* Unfortunately, because nothing is known of the distal part of the tarsometatarsus, it cannot be compared with *P. tirarensis* or *P. cadimurka,* although it is clearly in this size range.

P. cautleyi and *P. sivalensis,* based on distal ends of ulnae from the Pliocene of India are smaller than the living *P. conspicillatus,* (Miller, 1966) and although within the size range of *P. tirarensis* and *P. cadimurka,* cannot be compared directly.

P. odessanus from the early Pliocene of Russia is similar in size to the living *P. conspicillatus,* thus larger than *P. tirarensis* and *P. cadimurka.* It differs from *P. conspicillatus* in the shape of the trochlea, ridges, and muscle scars of the tarsometatarsus (Miller, 1966).

STRATIGRAPHIC DISTRIBUTION OF PELECANIDAE WITHIN AUSTRALASIA

Fossil pelicans are known from three parts of the stratigraphic column in Australasia, and direct correlation with sediments bearing pelecanid fossils elsewhere in the world is only approximate.

P. tirarensis occurs in the Etadunna Formation and possibly the Wipajiri Formation of the Lake Eyre Basin, Central Australia. The Etadunna Formation overlies fluviatile rocks dated as Paleocene-Eocene because of contained plant remains. Unfortunately, none of the vertebrate bearing sediments has datable plant remains, and lithologic correlation must be used to tie the vertebrate bearing outcrops with subsurface geologic sections bearing such plant remains. Further correlation with plant-bearing marine sections to the south allow a tentative assignment of the Etadunna rocks to a mid-Tertiary, Oligo-Miocene age (Stirton *et al.* 1968). Correlation by use of fossil mammal remains with the Namba Formation, further to the southeast, which bears pollen basally, suggests a post Batefordian—Balcombian age of about 14-16 million years BP (Tedford, et al., 1977). Based primarily on marsupial mammalian correlations, the Wipajiri Formation, which is channelled into the Etadunna, is thought to be of mid to late Miocene age. (See Rich, 1979 for a summary of the stratigraphy).

The remaining fossil pelicans of Australia have been collected from a number of sites along Cooper Creek, at Lake Kanunka (north of Cooper Creek), and along the Warburton River, all in the Lake Eyre Basin of northeastern South Australia; and on the Darling Downs of southeastern Queensland. All of these have been called Quaternary or Pleistocene in age. Locales along the Cooper and Warburton Rivers include fossils found both as 'float' on the surface and in place and are often associated with marsupials normally restricted to Pleistocene—aged sediments within Australia. Because many were collected out of a stratigraphic context, placement within the Pleistocene or even within the Recent is not certain. Dating of the Darling Downs vertebrates is based primarily on correlation using marsupial mammals, some species of which are entirely restricted to the Pleistocene, while others range from Pleistocene into the Recent.

New Zealand pelican fossils are known from several localities on both North and South Islands. All are no older than Holocene (see above).

DISCUSSION AND CONCLUSIONS

Pelecanus conspicillatus is the only extant pelican in Australasia. This has certainly not always been the case. During the last 2 million years, in the Quaternary, as many as 3 species were present in this biogeographic province, including: a small, gracile form, *P. cadimurka,* n. sp.; a very large, robust species, *P. novaezealandiae;* as well as a form

osteologically indistinguishable from the extant *P. conspicillatus*. *P. conspicillatus* and *P. cadimurka* were sympatric and contemporaneous in central Australia, a situation reflected by the modern broad geographic overlap of the small *P. rufescens* and the large *P. onocrotalus* in Africa. Likewise, the possible sympatry of *P. conspicillatus* and *P. novaezealandiae* is mirrored in the modern avifauna by the overlap of the large pelicans, *P. crispus* (the more gracile form) and *P. onocrotalus* (the more robust form) in the western Palaearctic. In fact, *P. novaezealandiae*, known only as a fossil from New Zealand, was contemporaneous with *P. conspicillatus* in Australia, suggesting probable overlap in distribution for such large mobile birds.

Only one other fossil pelican species is known from Australia, *Pelecanus tirarensis*, of Miocene age. It was a small form morphologically distinct from all later species.

Our review of all the Australasian fossil pelicans and comparison with all the recent pelicans support the inclusion in the synonomy of *P. conspicillatus* of: *P. validipes*, *P. grandiceps* and in part *Archaeocycnus lacustris*. Although we agree with Miller (1966) that of the three specimens De Vis referred to *P. proavus*, one is not of a pelican and the other two may be referred to *P. conspicillatus*, the illustrations of the lost holotype suggest a pelican distinct from *P. conspicillatus*. Thus, determination of the status of *P. proavus* is impracticable unless the holotype is relocated. Provisionally the name should be retained. Our review has also demonstrated the necessity for recognizing as a new species of small and gracile pelican, *P. cadimurka*, and for elevating to specific status *P. noveazealandiae*, which Scarlett had named as a sub-species of *P. conspicillatus*.

As a result of this study, we have been impressed by the uniformity in skeletal morphology of the pelican species we examined, except for that of the New World Brown Pelican, *P. occidentalis*. Being the only diving pelican it is so distinctive in many aspects of its biology and morphology, that further study may well indicate it meriting separated generic status in *Leptopelicanus* Reichenbach 1852 (1853), Avium Syst. Nat.: 7.

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TABLE 1

Fossil specimens assigned to the genus *Pelecanus* from the Cainozoic of Australasia

Specimen Number	Element	Old Name	New Name	Specimens available to: De Vis (1905)	A.H. Miller (1966)	PVR GFvT (this paper)
AMNH 11494	p. R. tarsometatarsus	—	rf. *tirarensis*	—	—	✓
Lost, De Vis	d. L. tarsometatarsus	*proavus* (holotype)	? *proavus*	✓	—	—
SAM P13858	d. R. tarsometatarsus	*tirarensis* (holotype)	*tirarensis*	—	✓	✓
SAM P18412	d. R. tarsometatarsus	*validipes* (holotype)	rf. *conspicillatus*	✓	—	✓
SAM P22501	d. L. tarsometatarsus	—	*cadimurka*, n. sp. (holotype)	—	—	✓
QM F1141	p. R. carpometacarpus	*proavus*	not pelican	✓	✓	✓
QM F3749	L. quadrate	*grandiceps*	rf. *conspicillatus*	✓	✓	✓
QM F3750	L. coracoid	*grandiceps*	rf. *conspicillatus*	✓	✓	✓
QM F3751	d. L. tarsometatarsus	*grandiceps* (lectotype)	rf. *conspicillatus*	✓	✓	✓
QM F3752	d. R. femur	*proavus*	rf. *conspicillatus*	✓	✓	✓
QM F3753	d. R. tibiotarsus	*proavus* (syntype)	rf. *conspicillatus*	✓	✓	✓
QM F5529	4th cervical vertebra	*Archaeocycnus lacustris*	rf. *conspicillatus*	✓	—	✓
QM F6669	L. coracoid	—	rf. *conspicillatus*	—	—	✓
QM F10703	d. L. tarsometatarsus	—	rf. *tirarensis*	—	—	✓
UCMP 56321	L. quadrate	*conspicillatus*	rf. *conspicillatus*	—	✓	✓
UCMP 56322	d. L. tarsometatarsus	*grandiceps*	rf. *conspicillatus*	—	✓	✓
UCMP 56348	d. L. ulna	*conspicillatus*	rf. *conspicillatus*	—	✓	✓
UCMP 56394	3rd cervical vertebra	*conspicillatus*	rf. *conspicillatus*	—	✓	✓
UCMP 56633	R. scapula	—	rf. *conspicillatus*	—	—	✓
UCMP 60477	p. R. femur	*conspicillatus*	rf. *conspicillatus*	—	✓	✓
UCMP 60487	L. coracoid	*conspicillatus*	rf. *conspicillatus*	—	✓	✓
UCMP 60503	L. cuneiform	*conspicillatus*	rf. *conspicillatus*	—	✓	✓
UCMP 60520	d. L. ulna	*conspicillatus*	rf. *conspicillatus*	—	✓	✓
UCMP 60521	d. R. tibiotarsus	*conspicillatus*	rf. *conspicillatus*	—	✓	✓
UCMP 60549	R. cuneiform	*conspicillatus*	rf. *conspicillatus*	—	✓	✓
UCMP 60577	d. R. tarsometatarsus	*conspicillatus*	rf. *cadimurka*, n. sp.	—	✓	✓
UCMP 60578	d. R. tarsometatarsus	*conspicillatus*	rf. *cadimurka*, n. sp.	—	✓	✓
UCMP 60640	d. L. humërus	*conspicillatus*	rf. *conspicillatus*	—	✓	✓
UCMP 60656	Ant. sternum	*conspicillatus*	rf. *conspicillatus*	—	✓	✓
UCMP 60702	fused palatines	*conspicillatus*	rf. *conspicillatus*	—	✓	—
UCMP 60988	d. R. tarsometatarsus	—	rf. *tirarensis*	—	—	✓
UCMP 69587	p. R. humerus	*conspicillatus*	Accipitridae	—	✓	✓
UCMP 113115	d. R. tarsometatarsus	—	rf. *tirarensis*	—	—	✓
UCMP 123382	4th cervical vertebra	—	rf. *cadimurka* n. sp.	—	✓	✓
				Archey (1931)	Scar-lett (1966)	PVR GFvT
CM AV12264	R. humerus	*conspicillatus novaezealandiae*	rf. *novaezealandiae*	—	✓	✓
CM AV12482	d. L. femur	*conspicillatus novaezealandiae*	rf. *novaezealandiae*	—	✓	✓
CM AV13095	p. R. humerus	*conspicillatus novaezealandiae*	rf. *novaezealandiae*	—	✓	✓
CM AV15089	R. coracoid	*conspicillatus novaezealandiae*	rf. *novaezealandiae*	—	✓	✓
CM AV21355	partial skeleton	*conspicillatus novaezealandiae* (holotype)	*novaezealandiae*	—	✓	✓
CM AV32001	part of fused furcula and sternum	—	rf. *novaezealandiae*	—	—	✓
Lost, Archey	partial skeleton	*conspicillatus novaezealandiae*	rf. *novaezealandiae*	✓	✓	—
AWNM AV5845.1	d. L. tibiotarsus	—	rf. *novaezealandiae*	—	—	✓
Horn, no No.	L. tibiotarsus	—	rf. *novaezealandiae*	—	—	✓

TABLE 2

Measurements in mm of tarsometatarsi of recent and Australasian fossil pelicans

	Width of distal end				At proximal end of distal foramen Width of shaft				Depth of shaft			
	n	range	$\bar{x}$	sd	n	range	$\bar{x}$	sd	n	range	$\bar{x}$	sd
FOSSIL												
P. tirarensis												
SAM P13858 type			19.6									
UCMP 60988 rf.							@12.0				8.3	
P. cadimurka												
UCMP 60577 rf.			18.5				14.2				8.8	
UCMP 60578 rf.			@19.3									
P. novaezealandiae												
CM AV21355 holotype			26.0				18.5				12.0	
Archey, lost, rf.			26.9 (Scarlett 1966)									
P. proavus from figures of holotype		>18.0-18.6				>14.8-15.2						
P. conspicillatus:												
SAM 18412 (holotype of *validipes*) rf.			26.1				17.9				11.0	
RECENT												
P. conspicillatus	20	21-26	24	1.5	19	15-19	17	1.4	19	9-12	11	0.8
P. crispus	1		25		9		18		1		11	
P. onocrotalus	3	24-30	27	3.3	3	17-22	20	2.5	3	11-16	13	2.3
P. erythrorhynchos	5	22-25	23	0.9	5	12-18	15	3.2	5	10-11	10	0.6
P. philippensis	1		25		1		19		1		12	
P. rufescens	2	19-24			2	14-18			2	9-12		
P. occidentalis	9	17-21	20	1.4	9	12-16	14	1.0	9	6-9	8	0.8

TABLE 3

Measurements in mm of trochlea III of tarsometatarsi of recent and Australasian fossil pelicans

	Internal depth				External depth				Distal width			
	n	range	$\bar{x}$	sd	n	range	$\bar{x}$	sd	n	range	$\bar{x}$	sd
FOSSIL												
P. tirarensis												
SAM P13858 holotype			11.3				11.2				9.4	
QM F10703 rf.			9.7				9.8				6.9	
UCMP 60988 rf.			>9.9				>10.3				@7.0	
UCMP 113115 rf.			@10.0				9.9				6.4	
P. cadimurka												
SAM P22501 holotype			9.2				9.6				>6.0	
UCMP 60577 rf.			>8.9				10.8				7.5	
UCMP 60578 rf.			11.5				12.0				7.2	
P. novaezealandiae												
CM AV21355 holotype			14.8				15.2				10.0	
P. proavus from figure of holotype											>6.8	
P. conspicillatus:												
SAM 18412 (holotype of *validipes*) rf.			15.0				15.3				10.1	
QM F3751 (lectotype of *grandiceps*) rf.			15.8				17.0				10.2	
UCMP 56322			15.3								10.1	
RECENT												
P. conspicillatus	19	12-16	14	1.0	20	13.17	15	1.0	17	8.10	9	0.6
P. crispus	1		14		1		14		1		10	
P. onocrotalus	2	14-17			3	14-16	15	1.3	2	9-10		
P. erythrorhynchos	5	13-14	13	0.4	5	13-14	14	0.4	2		9	
P. philippensis	1		14		1		14		1		9.5	
P. rufescens	2	11-14			2	12-14			1	7-9		
P. occidentalis	9	8-11	10	0.7	9	8-11	10	0.8	1		6	

TABLE 4

Measurements in mm of trochlea II and IV of tarsometatarsi of recent and Australasian fossil pelicans

	External depth of II				Anterior width of II				Internal depth of IV			
	n	range	$\bar{x}$	sd	n	range	$\bar{x}$	sd	n	range	$\bar{x}$	sd
FOSSIL												
P. tirarensis												
SAM P13858 holotype			10.2				4.5					
QM F10703 rf.			9.1				4.0					
P. cadimurka												
UCMP 60577 rf.							5.7				10.2	
UCMP 60578 rf.			10.6				5.5				11.2	
P. novaezealandiae												
CM AV21355 holotype			12.9								13.0	
P. proavus from figure of holotype							>5.6					
P. conspicillatus:												
QM F3751 (lectotype of *grandiceps*) rf.			>14.4									
SAM 18412 (holotype of *validipes*) rf.			13.5				7.8				14.0	
UCMP 56322 rf.			13.9									
RECENT												
P. conspicillatus	20	11-15	13	1.0	17	6-10	7	0.7	20	12-15	13	0.9
P. crispus	1		13		1		7		1		14	
P. onocrotalus	3	12-15	13	1.4	2	7-8			3	14-18	15	2.3
P. erythrorhynchos	5	12-13	12	0.4	2		7		5	12-13	13	0.4
P. philippensis	1		13		1		7		1		14	
P. rufescens	2	10-13			2	6-7			2	11-14		
P. occidentalis	9	8-11	10	0.7	1		5		9	8-11	10	0.7

TABLE 5

Measurements in mm of distal end of femora of recent and Australasian fossil pelicans

	Width of distal end				Width across internal and external condyles			
	n	range	$\bar{x}$	sd	n	range	$\bar{x}$	sd
FOSSILS								
P. novaezealandiae								
CM AV21355 holotype			36.2				28.4	
CM AV12482 rf.			>35				>28.3	
Archey, lost, rf.			38 (Scarlett 1966)					
P. conspicillatus:								
QM F3752 rf.			@29.0				24.4	
RECENT								
P. conspicillatus	15	30-37	32	2.2	15	24-29	26	1.7
P. crispus	2	35-37			2	27-29		
P. onocrotalus	2	33-35			2	26-29		
P. erythrorhynchos	9	28-33	31	1.9	9	24-27	25	0.9
P. philippensis	1		35		1		26	
P. rufescens	2	26-32			2	21-25		
P. occidentalis	5	20-26	23	1.8	5	16-19	19	2.1

TABLE 6

Measurements in mm of distal end of tibiotarsus of recent and Australasian fossil pelicans

	Internal depth of condyles				External depth of condyles				Width of shaft at proximal end of supratendinal bridge				Width of distal end			
	n	range	$\bar{x}$	sd	n	range	$\bar{x}$	sd	n	range	$\bar{x}$	sd	n	range	$\bar{x}$	sd
FOSSIL																
P. novaezealandiae																
CM AV21355 holotype			27.4				23.0				19.6				24.0	
AWNM AV5845.1 rf.											22.1				24.8	
Horn, no No. rf.			25.1				20.4				19.9				22.8	
Archey, lost rf.														(Scarlett 1966)	26.2	
P. conspicillatus																
QM F3753 rf.							⩾22.4								⩾23.2	
UCMP 60521 rf.			>20.7								19.1					
RECENT																
P. conspicillatus	15	24-28	26	1.3	15	19-23	21	1.2	15	16-23	20	1.8	15	20-25	22	1.3
P. crispus	1		29		1		24						1		26	
P. onocrotalus	3	25-32	29	3.5	3	22-25	24	1.7	3	20-24	21	2.0	3	22-27	25	2.6
P. erythrorhynchos	5	23-27	25	1.3	4	21-22	21	0.5	5	18-19	19	0.6	5	22-23	23	0.3
P. rufescens	1		28		1		23		1		20		1		24	
P. occidentalis	9	17-21	20	1.5	9	14-19	17	1.5	9	12-17	15	1.4	9	14-19	17	1.4

TABLE 7

Measurements in mm of fourth cervical vertebrae of recent and Australasian fossil pelicans

	Length from prezygapophyses to posterior of neural arch				Width across prezygapophyses				Width across posterior of centrum				Width across postzygapophyses			
	n	range	$\bar{x}$	sd	n	range	$\bar{x}$	sd	n	range	$\bar{x}$	sd	n	range	$\bar{x}$	sd
FOSSIL																
P. conspicillatus QM F5529 (syntype of *Archaeocycnus lucustris*) rf.										⩱12.1				⩱19.9		
P. cadimurka UCMP 123382 rf.			32.4				15.6				8.3				@13.9	
RECENT																
P. conspicillatus	11	52-66	60	4.7	11	21-25	23	1.7	11	11-14	13	1.0	10	19-23	21	1.3
P. crispus	1		55		1		22		1		13		1		21	
P. onocrotalus	2	49-53			2	22-23			2	12-13			2	21-23		
P. erythrorhynchos	2	49-50			2	20-23			2	11-12			2	19-21		
P. philippensis	1		44		1		18		1		11		1		16	
P. rufescens	2	44-46			2	19-20			2	10-12			2	16-20		
P. occidentalis	1		37		1		17		1		9		1		16	

TABLE 8

Measurements in mm of quadrates of recent and Australasian fossil pelicans

	Height from mandibular to squamosal articulation				Width across mandibular articulation				Width across orbital process			
	n	range	$\bar{x}$	sd	n	range	$\bar{x}$	sd	n	range	$\bar{x}$	sd
FOSSIL												
P. conspicillatus												
QM F3749 rf.			33.9				27.0					
UCMP 56321 rf.			@31.5				>23.3			>24.6		
RECENT												
P. conspicillatus	11	28-36	32	2.3	11	22-27	26	1.9	11	24-30	28	2.1
P. crispus	1		32		1		24		1		26	
P. onocrotalus	1		40		1		30		1		30	
P. erythrorhynchos	1		29		1		23		1		24	
P. philippensis	1		33		1		24		1		27	
P. rufescens	2	29-33			2	20-25			2	22-26		
P. occidentalis	1		32		1		20		1		19	

TABLE 9

Measurements in mm of coracoids of recent and Australasian fossil pelicans

	Width of shaft at coracoidal fenestra				Width from coracoidal fenestra to medial margin of shaft on posterior surface			
	n	range	$\bar{x}$	sd	n	range	$\bar{x}$	sd
FOSSILS								
P. conspicillatus:								
QM F3750 rf.			@19.4				8.4	
QM F6669 rf.			17.4				7.0	
P. novaezealandiae								
CM AV21355 holotype			16.8				9.7	
CM AV15089 rf.			@17.5				8.7	
RECENT								
P. conspicillatus	13	14-19	16	1.7	13	6-9	7	1.0
P. crispus	2	17-20			2	7-9		
P. onocrotalus	2	18-19			2		9	
P. erythrorhynchos	9	14-18	16	1.0	9	6-9	7	1.1
P. philippensis	2	18-19			2	8-9		
P. rufescens	2	13-16			2	5-8		
P. occidentalis	5	11-13	11	0.7	5	5-6	5	0.4

TABLE 10

Measurements in mm of third cervical vertebrae of recent and Australasian fossil pelicans

	Width across prezygapophyses				Width of anterior articular surface of centrum				Length of left side of anterior articular surface of centrum			
	n	range	$\bar{x}$	sd	n	range	$\bar{x}$	sd	n	range	$\bar{x}$	sd
FOSSIL												
P. conspicillatus UCMP 56394 rf.			24.9				16.1				9.8	
RECENT												
P. conspicillatus	9	22-26	24	1.4	9	11-14	12	0.9	9	7-11	10	1.5
P. crispus	1		23		1		12		1		11	
P. onocrotalus	2	23-26			2	11-12			2		10	
P. erythrorhynchos	2	21-23			2	11-12			2	9-11		
P. philippensis	1		18		1		10		1		8	
P. rufescens	2	19-21			2	11-12			2	8-10		
P. occidentalis	1		16		1		9		1		6	

TABLE 11

Measurements in mm of left prezygapophyses of third cervical vertebrae of recent and Australasian fossil pelicans

	Length				Width			
	n	range	$\bar{x}$	sd	n	range	$\bar{x}$	sd
FOSSIL								
P. conspicillatus UCMP 56394 rf.			11.5				6.3	
RECENT								
P. conspicillatus	9	10-14	12	1.3	9	5-7	6	0.5
P. crispus	1		12		1		6	
P. onocrotalus	2		11		2	6-7		
P. erythrorhynchos	2		11		2	4-5		
P. philippensis	1		9		1		5	
P. rufescens	2	9-10			2		5	
P. occidentalis	1		10		1		4	

TABLE 12

Measurements in mm of sterna at coracoidal sulci of recent and Australasian fossil pelicans

	Depths across right dorsal and ventral lips at maximum expansion				Depths across left dorsal and ventral lips at maximum expansion				Minimum distance between sulci			
	n	range	$\bar{x}$	sd	n	range	$\bar{x}$	sd	n	range	$\bar{x}$	sd
FOSSIL												
P. conspicillatus UCMP 60656 rf.			13.9				16.2				4.4	
RECENT												
P. conspicillatus	10	13-18	16	1.4	10	13-19	16	1.7	10	0-7	4.5	2.3
P. onocrotalus	1		21		1		19		1		10	
P. erythrorhynchos	5	9-16	12	3.0	4	8-16	12	3.9	5	4-11	7.5	2.7
P. philippensis	1		18		1		17		1		9	
P. rufescens	1		16		1		17		1		6	
P. occidentalis	9	7-9	8	0.5	9	7-9	8	0.6	9	7-11	9	1.2

TABLE 13

Measurements in mm of distal end of ulnae of recent and Australasian fossil pelicans

	Width of distal end				Depth of external condyle				Width of shaft at proximal end of external condyle				Depth of internal condyle			
	n	range	$\bar{x}$	sd	n	range	$\bar{x}$	sd	n	range	$\bar{x}$	sd	n	range	$\bar{x}$	sd
FOSSIL																
P. novaezealandiae																
CM AV21355 holotype			24.4				21.6				17.5				15.5	
Archey, lost, rf.			25 (Scarlett 1966)													
P. conspicillatus																
UCMP 56348 rf.			22.1				20.2									
UCMP 60520 rf.			23.6				20.1				18.6				14.7	
RECENT																
P. conspicillatus	15	21-25	23	1.3	15	18-22	20	1.2	15	14-18	16	0.9	15	12-14	13	0.6
P. crispus	2	25-26					24		1		19		1		16	
P. onocrotalus	2	23-27			2	22-24			2	17-21			2	15-21		
P. erythrorhynchos	5	21-23	22	0.6	5	20-21	20	0.4	5	15-16	16	0.5	5	12-14	13	0.5
P. rufescens	2	20-24			2	18-20			2	15-16			2	12-15		
P. occidentalis	8	16-20	19	1.2	8	13-19	17	1.8	8	11-15	13	1.1	7	10-12	11	0.7

TABLE 14

Measurements in mm of cuneiforms of recent and Australasian fossil pelicans

	Width across ulnar articulation and opposite process				Height of ulnar articulation				Width of ulnar articulation				Height of opposite process			
	n	range	$\bar{x}$	sd	n	range	$\bar{x}$	sd	n	range	$\bar{x}$	sd	n	range	$\bar{x}$	sd
FOSSIL																
P. conspicillatus																
UCMP 60503 rf.			19.2				13.5				10.2				18.2	
UCMP 60549 rf.			17.5				13.9				9.2				17.6	
RECENT																
P. conspicillatus	12	17-20	19	0.9	12	12-17	14	1.3	12	8-10	9	0.7	12	16-20	18	1.5
P. crispus	1		25		1		17		1		14		1		22	
P. onocrotalus	2	21-23			2	16-18			2	10-12			2		19	
P. erythrorhynchos	1		19		1		16		1		10		1		19	
P. rufescens	2	17-18			2	13-14			2				2	16-19		
P. occidentalis	1		16		1		11		1		7		1		15	

TABLE 15

Measurements in mm of proximal end of femora of recent and Australasian fossil pelicans

	Width of proximal end				Depth of head				Depth of trochanter			
	n	range	$\bar{x}$	sd	n	range	$\bar{x}$	sd	n	range	$\bar{x}$	sd
FOSSIL												
P. novaezealandiae												
CM AV21355 holotype			35.4				15.1				5.0	
Archey, lost, rf.			36.0 (Scarlett 1966)									
P. conspicillatus												
UCMP 60477 rf.			29.7				14.5				> 25.5	
RECENT												
P. conspicillatus	14	26-33	29	2.0	14	13-16	14	0.8	14	22-27	24	1.5
P. crispus	2	31-34			2	15-16			2	25-26		
P. onocrotalus	1		30		1		15		1		24	
P. erythrorhynchos	5		29	0.3	5	13-14	14	0.3	5	22-25	24	1.2
P. philippensis	1		32		1		15		1		23	
P. rufescens	2	24-29			2	12-14			2	19-24		
P. occidentalis	9	19-25	23	2.0	9	9-12	11	1.1	9	16-22	19	1.7

TABLE 16

Measurements in mm of distal end of humeri of recent and Australasian fossil pelicans

	Length of external condyle				Depth of external condyle				Depth of internal condyle			
	n	range	$\bar{x}$	sd	n	range	$\bar{x}$	sd	n	range	$\bar{x}$	sd
FOSSIL												
P. novaezealandiae												
CM AV21355 holotype			22.7				26.5				14.8	
CM AV12264 rf.			>22				>27				@15	
P. conspicillatus												
UCMP 60640 rf.			20.7				>21.1				13.1	
RECENT												
P. conspicillatus	17	19-25	22	1.6	18	22.27	25	1.5	18	12-16	14	1.1
P. crispus	2	23-24			1		28				16	
P. onocrotalus	2	23-28			2	24-30			2	15-17		
P. erythrorhynchos	5	20-22	21	0.6	5	24.26	24	1.2	5	14-15	15	0.2
P. rufescens	2	18-22			2	21-25			2	12-15		
P. occidentalis	9	15-20	18	1.5	9	17-22	21	1.4	9	11-13	12	0.8

TABLE 17

Measurements in mm of scapulae of recent and Australasian fossil pelicans

	Total length				Width across glenoid facet				Width of shaft at distal end of glenoid facet			
	n	range	$\bar{x}$	sd	n	range	$\bar{x}$	sd	n	range	$\bar{x}$	sd
FOSSIL												
P. novaezealandiae CM AV21355 holotype							23.7				14.7	
P. conspicillatus UCMP 56633 rf.		>101.8				@21.2				@13.8		
RECENT												
P. conspicillatus	9	114-140	126	9.2	11	20-25	22	1.2	11	11-17	14	1.3
P. crispus	1		134		1		24				16	
P. onocrotalus	2	129-137			2	24-25			2	16-17		
P. erythrorhynchos	5	121-133	126	5.5	5	20-22	21	0.8	5	13-20	16	2.9
P. philippensis	2	129-137			2	24-25			2	16-17		
P. rufescens	2	101-119	101		1		2		2		16	
P. occidentalis	10	81-103	97	6.5	8	14-18	16	1.3	10	8-13	11	1.3

TABLE 18

Measurements in mm of synsacra of recent and Australasian fossil pelicans

	Length including anterior 3 fused vertebrae				Supratrochanteric width				Width of ilio-ischiatic foramen				Length of ilio-ischiatic foramen			
	n	range	$\bar{x}$	sd	n	range	$\bar{x}$	sd	n	range	$\bar{x}$	sd	n	range	$\bar{x}$	sd
FOSSIL																
P. novaezealandiae CM AV21355 holotype			285				97.5				23.5				47.5	
RECENT																
P. conspicillatus	12	241-287	271	1.6	21	79-95	88	5.2	20	17-23	20	1.7	20	42-56	50	3.7
P. onocrotalus	2	263-266			2	94-97			2	20-21			2	44-45		
P: erythrorhynchos	2	247-248			2	92-94			2	21-22			2	42-47		
P. rufescens	1		250		1		89		1		23		1		44	
P. occidentalis	1		221				69				14				29	

TABLE 19

Log_{10} ratios of width: length of synsacra and of ilio-ischiatic foramina of recent and Australasian fossil pelicans (cf. Table 18 and Northcote 1979)

	Synsacrum				Ilio-ischiatic foramen			
	n	range	$\bar{x}$	sd	n	range	$\bar{x}$	sd
FOSSIL								
P. novaezealandiae CM AV21355 holotype			0.47				0.31	
RECENT								
P. conspicillatus	12	0.47-0.51	0.49	0.01	20	0.33-0.48	0.40	0.04
P. onocrotalus	2	0.44-0.45			2	0.32-0.35		
P. erythrorhynchos	2	0.42-0.43			2	0.29-0.34		
P. rufescens	1		0.45		1		0.28	
P. occidentalis	1		0.42		1		0.31	

FIG. 1. Map of localities where fossil pelicans were found in Australasia. Map A: *Pelecanus proavus*, holotype (1); *P. novaezealandiae*, holotype (4), referred (2, 3 and 5); Map B: *P. tirarensis*, holotype (7), referred (6); *P. cadimurka* n. sp. holotype (10), referred (8, 13); *P. conspicillatus*, referred (8, 9, 11-14).

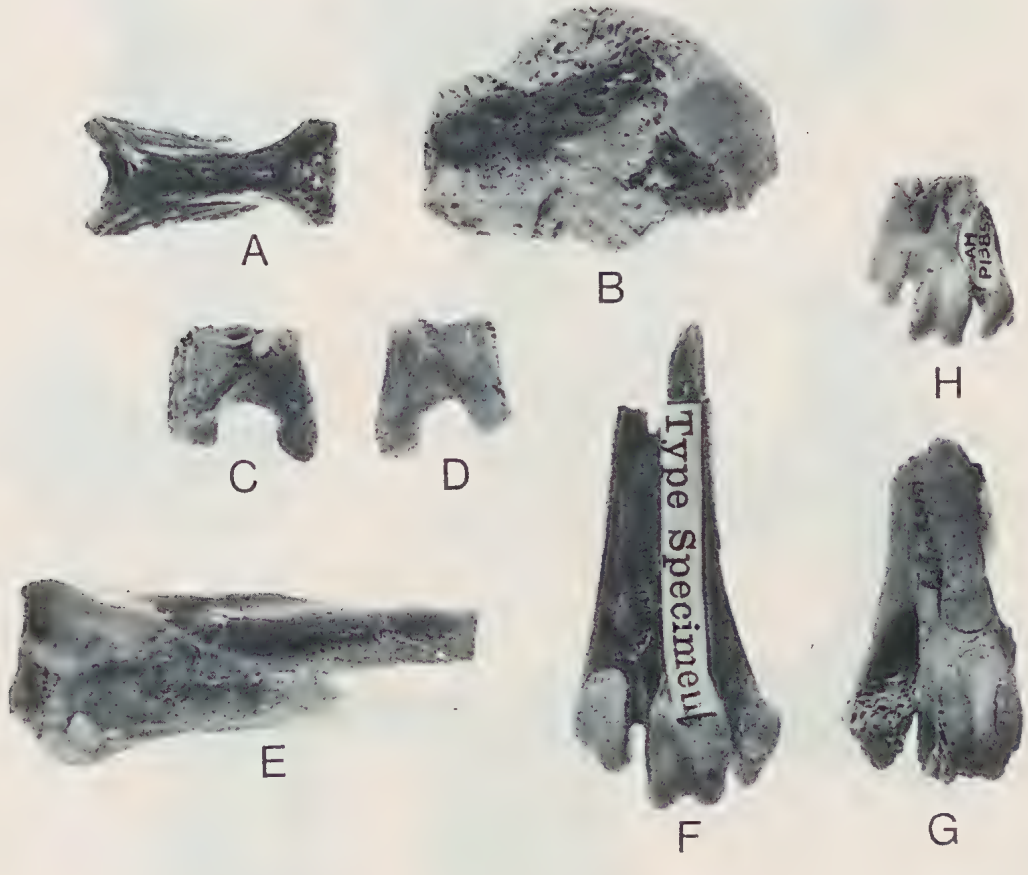

FIG. 2. Fossil pelicans of Australia. *Pelecanus* rf. *cadimurka*, UCMP 123382, fourth cervical vertebra (A); Accipitridae, UCMP 69587, proximal right humerus (B). *P.* rf. *conspicillatus*, UCMP 60503, left cuneiform (C); UCMP 60549, right cuneiform (D); UCMP 60520, distal left ulna fragment (E); *P. validipes*, holotype, SAM 18412, distal right tarsometatarsus (F); *P. grandiceps*, lectotype, QM F3751, distal left tarsometatarsus (G); *P. tirarensis*, holotype, SAM P13858, distal right tarsometatarsus (H). See scale for size.

FIG. 3. Fossil pelicans of Australia. *Pelecanus* rf. *conspicillatus*, UCMP 60656, anterior sternal fragment (A); UCMP 56394 anterior 3rd cervical vertebra (B); *Archaeocycnus lacustris*, syntype, QM F5529, 4th cervical vertebra (C); rf. *P. conspicillatus*, QM F3749, left quadrate fragment (D); UCMP 56321, left quadrate (E); UCMP 60640, distal left humerus (F); UCMP 56633, right scapula (G); *P.* rf. *tirarensis*, UCMP 113115, distal right tarsometatarsus (H); UCMP 60988, distal right tarsometatarsus (I); *P.* rf. *conspicillatus*, UCMP 56322, distal left tarsometatarsus (J); *P.* rf. *cadimurka*, UCMP 60577, distal right tarsometatarsus (K); UCMP 60578, distal right tarsometatarsus (L). See scale for size.

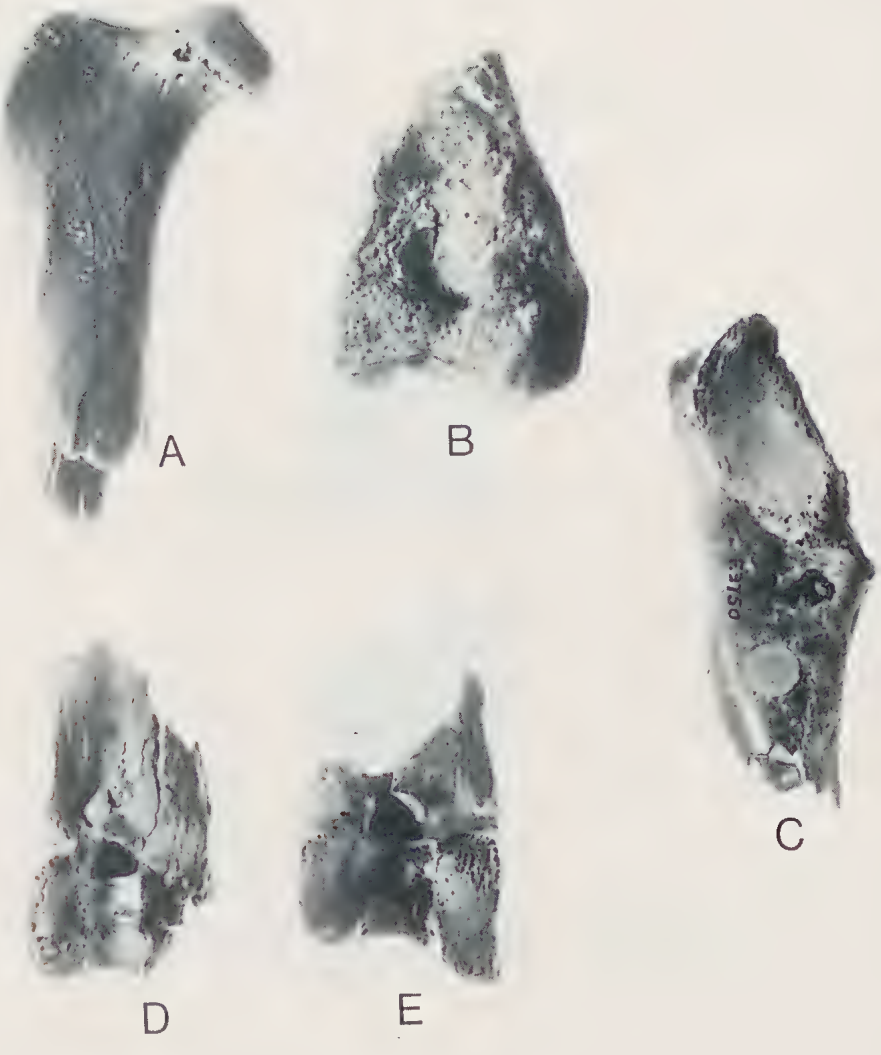

FIG. 4. Fossil pelicans of Australia. *Pelecanus* rf. *conspicillatus*, UCMP 60477, proximal right femur, (A); QM F3752, distal right femur, (B); QM FF3750, left coracoid fragment, (C); UCMP 60521, distal right tibiotarsus, (D); QM F3753, distal right tibiotarsus, (E). See scale for size.

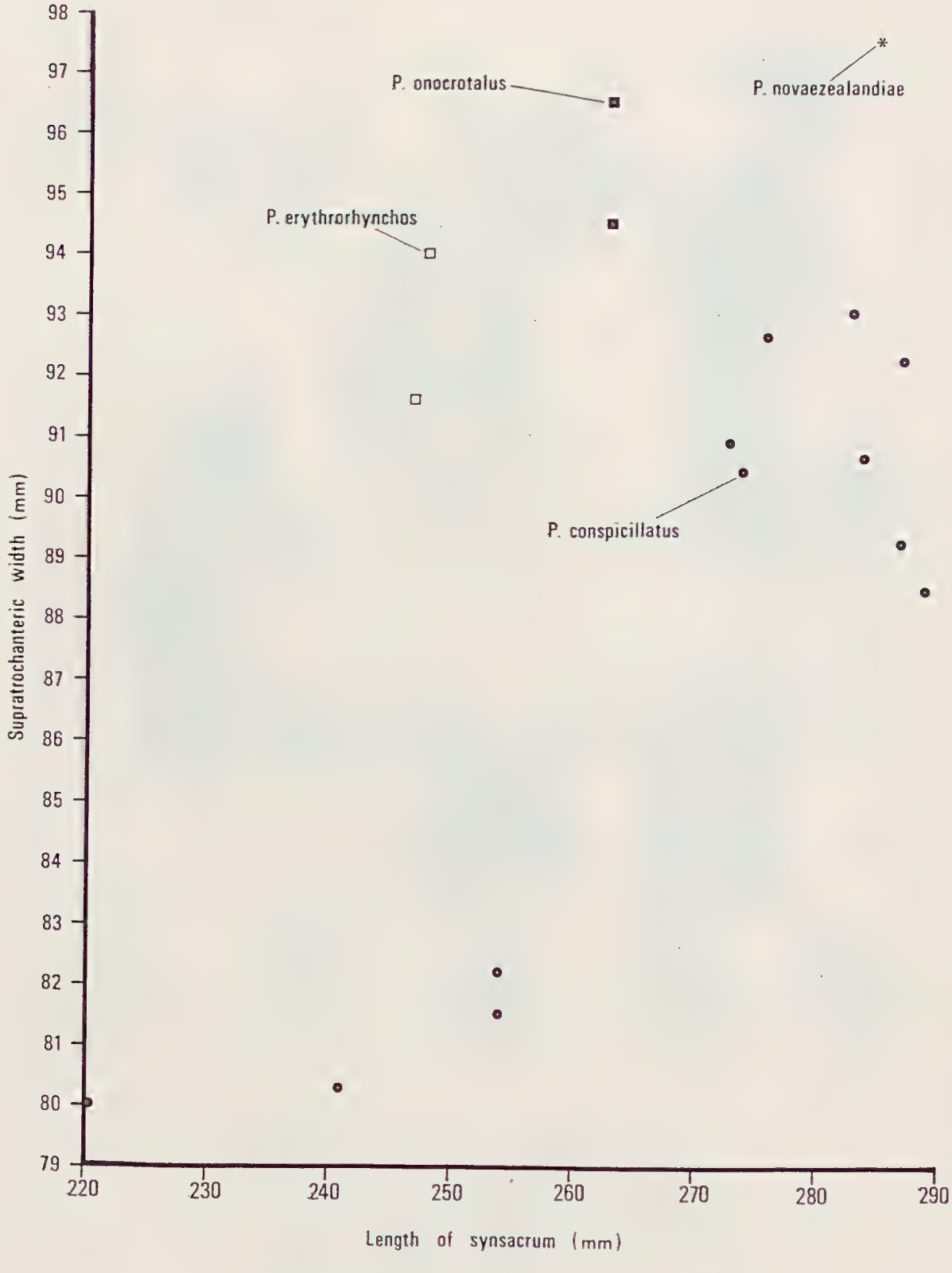

FIG. 5. Comparison of synsacral measurements of the large species of *Pelecanus*.

FIG. 6. Holotype of *Pelecanus cadimurka*, n. sp., SAM P22501, distal left tarsometatarsus. A. Anterior view. B. Distal view.

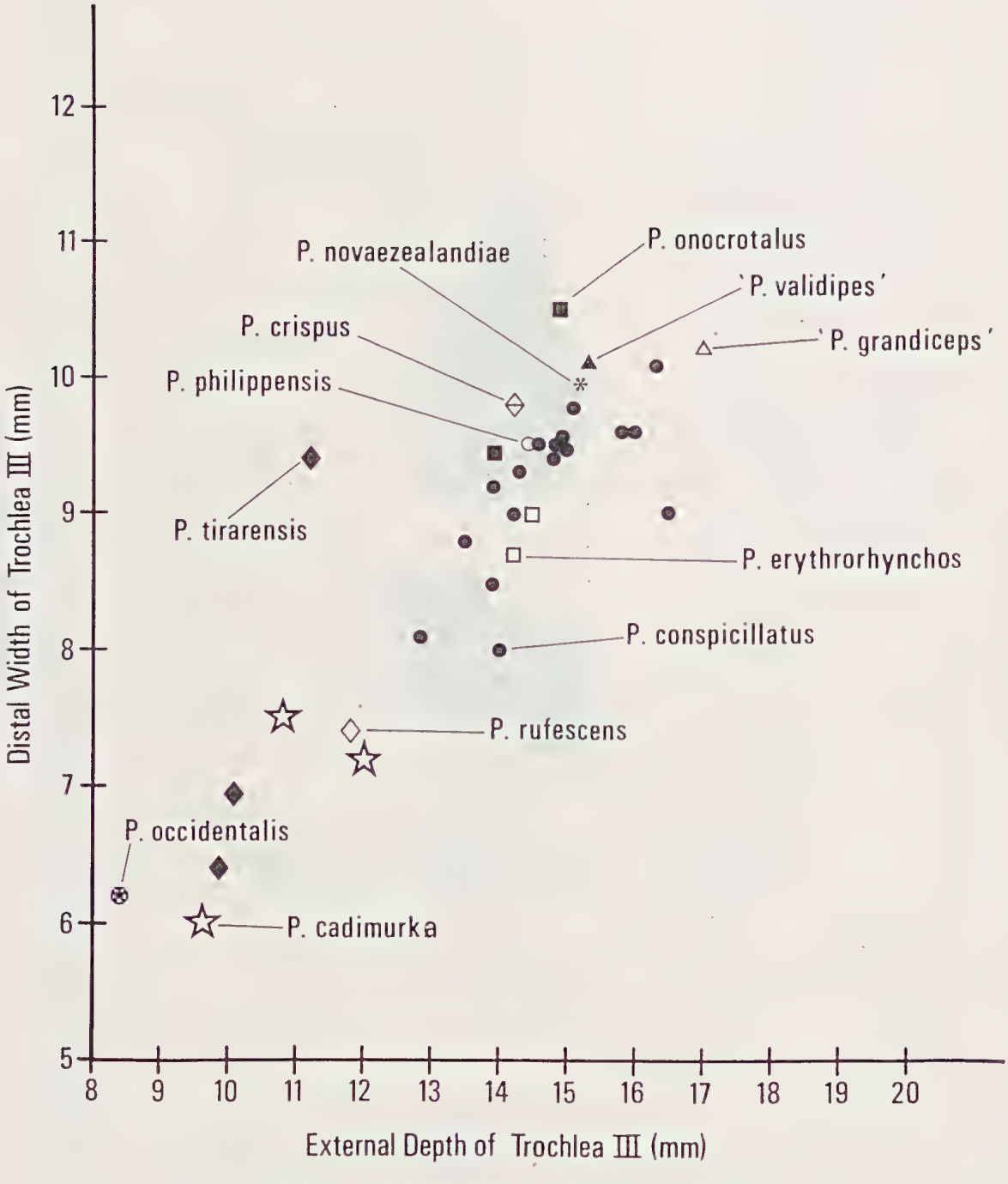

FIG. 7. Comparison of distal tarsometatarsal measurements of living and extinct species of *Pelecanus*.

ON SOME OVIPAROUS FILARIAL NEMATODES MAINLY FROM AUSTRALIAN BIRDS[1]

by

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ABSTRACT

BAIN, O., and MAWSON, P. M. 1981. Some oviparous filarial nematodes mainly from Australian birds. *Rec. S. Aust. Mus.* **18**(13): 265-284.

Three groups of filarial nematodes are represented in this collection.

1. Aproctinae.

Four species are described: *Pseudaprocta copemani* n.sp. from *Petroica multicolor: Aprocta boulengeri* n.sp. from *Strepera graculina; Aprocta bakeri* n.sp. from *Corvus orru; Lissonema* sp. from *Ninox novaeseelandiae.*

Pseudaprocta is regarded as being closely linked with the Seuratoidea.

The species assigned to *Aprocta* are heterogeneous, falling into two distinct morphological groups, one of which corresponds with the genus *Lissonema,* which is therefore reinstated. *Aprocta* spp. have a short ovejector, small caudal papillae in males, spicules generally subequal with fine distal extremities, no deirids, small eggs (less than 55 μm long), short larvae (around 200 μm long) with short tail bearing terminal spines. *Lissonema* spp. have a long ovejector, at least one large caudal papilla in male, spicules usually equal, with large blunt distal extremities, deirids, large eggs (more than 65 μm long), long larvae (more than 400 μm long) with long unarmed tail. The genus *Squamofilaria* is regarded as a synonym of *Lissonema* and its species are shown to belong either to *Lissonema* or *Aprocta. Lissonema* contains 20 spp. (19 n. comb.) and *Aprocta* 17 spp. (2 n. comb). The host ranges of these two genera are completely different.

2. Dicheilonematinae.

Serratospiculum guttatum (Schneider, 1866) from *Falco longipennis* and *F. peregrinus,* and *S. tendo* (Nitzsch, 1819) from *F. peregrinus* are redescribed. *S. seurati* n.sp is described.

Serratospiculum, parasites of Falconidae, contains a total of seven species. These species fall within two groups depending on the spicule length. (1) Those with short spicules are separated further, in that *S. turkestanicum* Skrjabin, 1916, *S. guttatum, S. kwangsiensis* Hsü, 1963, possess specific cuticular ornamentations in the female; while *S. chungi* Hoeppli et Hsü, 1929, *S. seurati* n.sp. (= *F. attenuata* Rud., 1819 *sensu* Seurat, 1915), *S. congolensis* Vuylstecke 1957, are distinguished by the morphology of the epaulettes and the right spicule; (2) those with long spicules: *S. tendo* (= ? *S. thoracis* Tubangui, 1934; = ? *S. lii* Ezzat et Tadros, 1958).

3. Diplotriaeninae.

Three species are described: *D. spratti* n.sp. from *Oreoica gutturalis, D. beveridgei* n.sp from *Corvus orru, and D. smithi* n.sp from *Acanthogenys rufogularis.* Additional morphology is given for *D. delta* Johnston and Mawson, 1940 and *D. falconis* (Connal, 1912).

DEPOSITION OF TYPE MATERIAL

Holotypes and allotypes have been deposited in the South Australian Museum, Adelaide; (SAM in text); other material has been deposited as noted, in the Muséum National d'Histoire Naturelle, Paris (MNHN) and in the Australian Helminthological Collection (AHC) at present housed in the South Australian Museum.

In the species described here, the female has been designated as holotype, and the male as allotype. This is because the family, genera and species of filarial worms are more often identified by the female than by the male.

DESCRIPTION OF MATERIAL

I. Aproctoidea—Aproctinae

Genus Pseudaprocta Schikhobalova

The morphological characters of the genus *Pseudaprocta* are closer to those of Seuratoidea Ascaridida than of Spirurida (Chabaud, 1974): mouth large and triangular, six external labial papillae, situated on the same circle as the cephalic papillae, oesophagus short and very thick, without

[1] This study was carried out while working under a grant (to O.B.) from the World Health Organisation.

differentiation into two parts, spicules equal and simple, and one pair of caudal papillae situated laterally (8th pair).

It seems that *Pseudaprocta,* and possibly the Aproctinae, evolved from the Seuratoidea.

Pseudaprocta copemani n.sp.

(Figs. 1, 2,)

Material examined

From *Petroica multicolor* Gmelin (Muscicapidae) from Maggs Mt, Tasmania. Holotype ♀, allotype ♂ (SAM V2096, V2097), 1♀ and 1♂ (MNHN, Paris, No. 201 HD); 2♀ and 3♂ (AHC 6277).

From *Pachycephala pectoralis* Latham (Muscicapidae), from Heatherleigh, S. Aust.: 3 pieces of ♀ (2 anterior, 1 posterior), 1♂, 1 posterior end ♂. (AHC 6282).

Description

Morphology is shown in Figures 1 and 2. The specimens, except in one case, are surrounded with a thin membrane detached from the rest of the cuticle and forming a vesicle around the body, beginning at the level of the oesophagus and ending at the level of the tail.

In the female, the tail ends in a small rounded knob (Fig. 1, I). In the male, the precloacal unpaired papilla is particularly big (Fig. 2, B and C). The spicule sheaths are thickened near the cloaca; these thickenings apparently assume the role of a gubernaculum (Fig. 2, E).

Measurements

Holotype ♀: body length 16.5 mm, width 500 μm; nerve ring, deirids and vulva at 160 μm, 320 μm and 370 μm from head; length of buccal capsule 25 μm; length of oesophagus 585 μm; length of tail 320 μm.

Allotype ♂: length of body 8.9 mm; width 310 μm; nerve ring 160 μm from head; length of oesophagus 520 μm; length of left spicule, right spicule and tail respectively 640 μm, 600 μm, 190 μm.

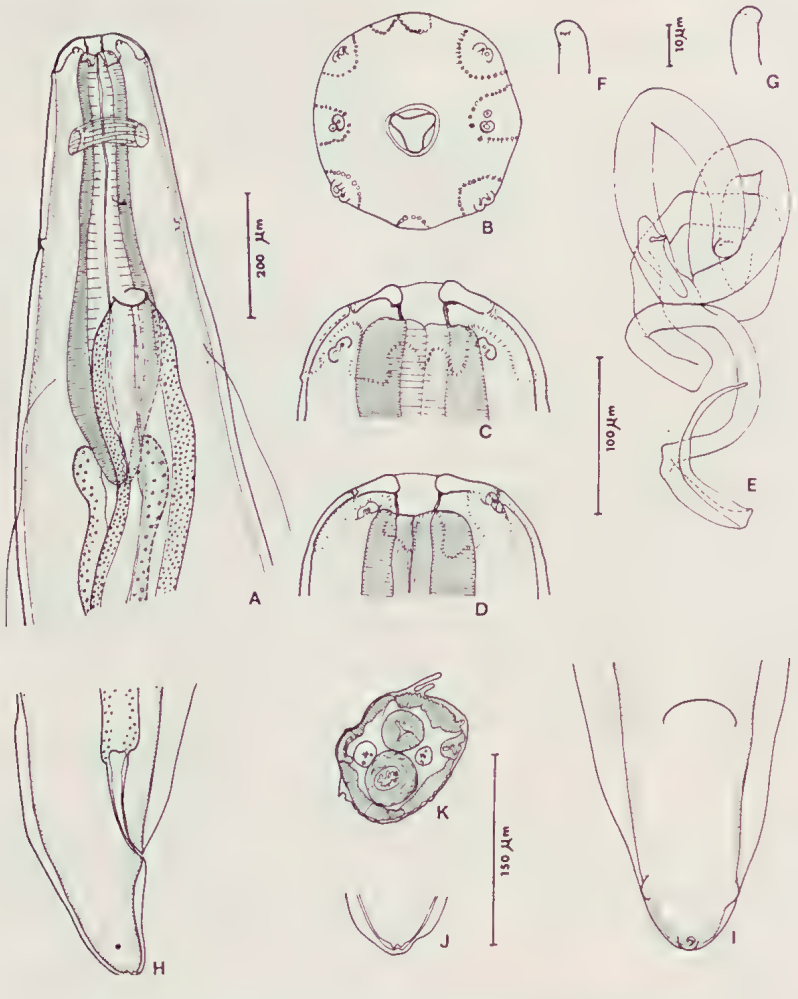

Figure 1. *Pseudaprocta copemani* n.sp., female. A, anterior end, ventral view; B, C, & D, head in apical, dorsal and ventral views; E, larva; F & G, head of larva, from hook side and opposite side; H & I, tail in lateral and ventral views; J, tip of tail; K, transverse section of body. A, H, I, J, K, to scale 200 μm; B, C, D, to scale 100 μm; E, F, G, to scale 10 μm.

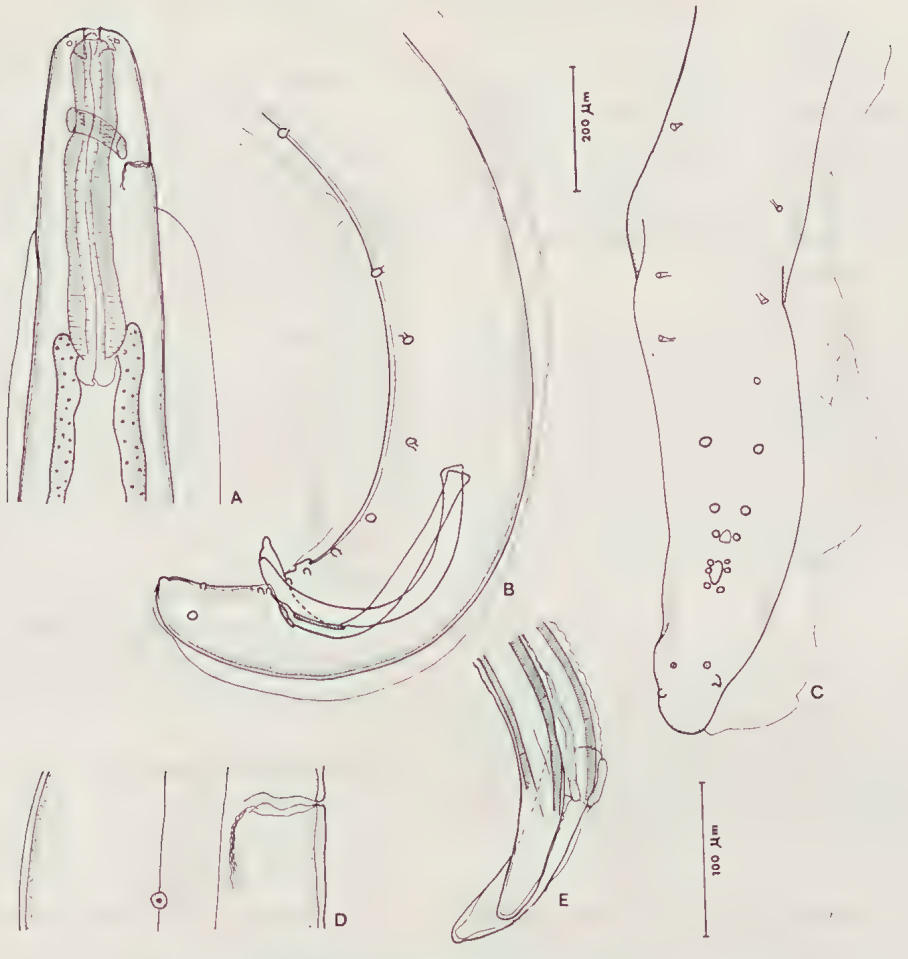

Figure 2. *Pseudaprocta copemani* n.sp., male. A, anterior end, lateral view; B & C, caudal region, lateral and ventral views; D, region of deirid and excretory pore, lateral view; E, distal extremities of spicules and gubernaculum, lateral view. A, B, C, to scale 200 µm; D, E, to scale 100 µm.

Paratype ♀: body length 18 mm; width 520 µm; nerve ring, deirids, excretory pore and vulva at 152 µm, 320 µm, 270 µm and 435 µm from head; buccal capsule 25 µm long; egg 52 µm × 42 µm; larva 480 µm × 8µm.

Another ♂ from AHC6277: body length 9 mm long, width 400 µm: nerve ring, deirids and excretory pore 160 µm, 290 µm and 230 µm from head; buccal capsule 22 µm long; oesophagus 440 µm long; length of left spicule, right spicule and tail respectively 550, 575 and 200 µm.

Discussion

This material is distinguished by its longer spicules from *P. gubernaculum* Schikhobalova, 1930 (Caucasia); *P. decorata* Li, 1933 (China); *P. buckleyi* (Singh, 1949) and *P. leiperi* (Rasheed, 1960) (India), and *P. ungriai* Chabaud *et al.*, 1964 (Madagascar), in which the spicules are about 400 µm long. It differs from *P. sichotealinensis* Oshmarin & Belouss, 1951 from Eastern USSR (Sonin, 1966) and *P. skrjabini* (Ali, 1956) from India, by the rather greater spacing, longitudinally, of the papillae near the cloaca. *P. myzanthae* Johnston & Mawson, 1940, from *Myzantha flavigula* (Meliphagidae) from South Australia, is known only by the female, the measurements of which are very similar to those of the present specimens with the exception of the body length which is greater. It seems better to keep the two species separate, in view of the difference in hosts, and of the fact that Johnston & Mawson show a slightly different arrangement of the cephalic spines (Johnston & Mawson, 1940, fig. 14). We therefore propose it as a new species, *P. copemani*, in honour of our Australian colleague Bruce Copeman.

The Genera **Aprocta** Linstow, **Lissonema** Linstow, and **Squamifilaria** Schmerling

The genus *Aprocta* according to Anderson and Bain (1976), is large and heterogenous. Some authors (Boulenger, 1928; Sandground, 1933 etc . . .) had previously proposed to recognize two genera, *Aprocta* Linstow, 1883 and *Lissonema* Linstow, 1903, separated on the form of the head (flat or with two lateral elevations), the oesophagus (divided or not), the caudal papillae of the male (few and small or large and numerous). As pointed out by

Anderson and Chabaud (1958) the two first of these characters are of doubtful use, because there are many species in which the division is not clear. However, since their work, further descriptions and redescriptions have been made (Ezzat and Tadros, 1958; Rasheed, 1960; Diaz-Ungria, 1963; Chabaud *et al.*, 1964; Schmidt and Kuntz, 1970; Yoyotte, 1972; Quentin *et al.*, 1976), so the morphology of the group is better understood.

It appears that the structure of the ovejector is of importance, as this can be either of two distinct types: it may be long (1500-5000 μm) often with the middle part dilated to form a chamber (e.g. *A. travassosi* Caballero, 1938) or very short (200-600 μm) and simple (e.g. *A.turgida* Stossich, 1902, in Chabaud and Choquet, 1955). Examination of well described species shows that the character "ovejector long" is found in species with large caudal papillae, and the character "ovejector short" is found in species with small papillae.

This division is borne out by other characters: spicules equal or unequal, with tips wide or fine, presence or absence of deirids, large or small eggs, larvae with long smooth tails (Chabaud *et al.*, 1959) or short spiny tails (Quentin *et al.*, 1976).

The two groups represent Linstow's two genera, *Aprocta* and *Lissonema*, and *Lissonema* is now reinstated. *Aprocta* Linstow, 1883: ovejector short; caudal papillae small; spicules generally subequal with distal extremity finely pointed; deirids absent; eggs small (less than 55 μm long); larvae short (about 200 μm), with short tail with terminal spines. Type species; *A.cylindrica* Linstow, 1883 (redescribed by Quentin *et al.*, 1976) from Passeriformes.

Other species sufficiently known to be allotted to the genus, with the bird groups in which they occur, are:

A. angolica (Vuylsteke, 1953); Passeriformes

A. caballeroi Ybarra, 1948; Falconiformes and Passeriformes

A. cercomelae Sonin, 1966; Passeriformes

A. colaptidis Schuurmans-Stekhoven, 1952; Passeriformes

A. crassa Railliet et Henry, 1910; Ralliformes

A. laevicutis (Sandground, 1933); Passeriformes

A. matronensis Railliet et Henry, 1910; Passeriformes

A. narium Linstow, 1901; Falconiformes

A. ophthalmophaga Stossich, 1902; Falconiformes

A. orbitalis Linstow, 1901; Falconiformes

A. ptiloscelidis Schuurmans-Stekhoven, 1952; Charadriiformes

A. sudarikowi Sobolev, 1947*; Charadriiformes et Ralliformes

A. textori Vuylsteke, 1953, Passeriformes

A. turgida Stossich, 1902 (redescribed by Chabaud et Choquet, 1955); Lariformes.

The species *A. caudata* Mendonca, 1961, of which only the male is known, seems to belong to the Splendidofilariinae.

Lissonema Linstow, 1903: ovejector long; at least one large caudal papilla (a single precloacal papilla, 0-4 pairs cloacal papillae); spicules generally equal, with distal extemity wide and blunt; deirids present; eggs large (over 65 μm long), larvae large (over 400 μm long), tail long unarmed. Type species: *L. rotundata* Linstow, 1903 (redescribed by Rasheed, 1960) parasitic in Cuculiformes.

Other species which are sufficiently known to be allotted to the genus, listed with the bird groups in which they occur, are:

L. brevicaudata (Chow, 1939) n.comb. (Strigiformes).

L. calliderma (Schmidt et Kuntz, 1970) n.comb. (Cuculiformes).

L. caprimulgi (Kazubski, 1958) n.comb. (Caprimulgiformes)

L. cosmetocephala (Yoyotte, 1972) n.comb. (Cuculiformes)

L. ghesquieri (Ezzat et Tadros, 1958) n.comb. (Caprimulgiformes).

L. golvani (Diaz-Ungria, 1963) n.comb. (Piciformes)

L. lepidogrammi (Tubangui et Masilungan, 1937) n.comb. (Cuculiformes.)

L. noctuae (Spaul, 1927) n.comb., redescribed by Chabaud (1951) (Strigiformes).

L. nyctidromi (Caballero et Peregrina, 1938) n.comb (Caprimulgiformes).

L. obtusa (Dujardin, 1845) n.comb. (= *Eucamptus obtusus* D., 1845, *Eucamptus* Chevr., 1833 preoccupied, Coleoptera) (Caprimulgiformes).

L. papillosa (Chabaud, Anderson et Brygoo, 1959) n.comb. (Cuculiformes).

L. proctata (Lent et Freitas, 1948) n.comb. (Strigiformes).

L. semenovi (Skrjabin, 1934) n.comb. (Caprimulgiformes).

*A. *sudarikowi* Sobolev, 1947 (*in* Sonin, 1966) is hard to classify: according to this author, the spicules are pointed and the eggs small as in *Aprocta* spp., but the caudal papillae are large as in *Lissonema* spp. The ovejector cannot be analysed. However, Sandground (1933) describing analogous material, emphasised the absence of caudal papillae. It seems to us that this species belongs to *Aprocta*.

L. spasskyi (Sonin, 1966) n.comb. (Cuculiformes).

L. travassosi (Caballero, 1938) n.comb. (Trogoniformes).

The genus *Squamofilaria* Schmerling, 1925, which was reinstated by Anderson and Chabaud (1958) for Aproctinae with a short well sclerotized buccal capsule, is itself heterogenous. In these species, the buccal capsule appears to be a secondary cuticularisation of the wall of the buccal cavity, as in *Lissonema* sp., described below from *Ninox novaeseelandiae*. It is poorly limited externally, as compared with the true buccal capsule seen in *Dipetalonema* spp., *Litomosa* spp., etc. which are descended from forms with a buccal capsule formed from rhabdions.

The species attributed to *Squamofilaria* fall into the same two morphological groups found in *Aprocta* and *Lissonema*, and can be allotted to one or other of these genera as follows:

(a) Aprocta

A. vestibulata (Johnston et Mawson, 1950) n.comb. (Passeriformes).

A. pillersi (Yorke et Maplestone, 1926) n.comb. (Passeriformes).

(b) Lissonema

L. coraciae (Gmelin, 1790) n.comb. syn. *Squamofilaria coraciae* (Gmelin, 1870). This is the type species of *Squamofilaria* which now falls as a synonym of *Lissonema* (Coraciadiformes).

L. sicki (Strachan, 1957) n.comb. (Strigiformes).

L. nepalensis (Soota et Chaturverdi, 1970) n.comb. (Coraciadiformes).

L. ungriai (Guerrero, 1971)* n.comb. (Trogoniformes).

It appears that the host ranges for *Lissonema* and *Aprocta* are mutually exclusive.

Lissonema spp. are known from the Strigiformes, the Cuculiformes†, the Piciformes (Bucconidae), the Trogoniformes, the Caprimulgiformes and the Coraciadiformes. It is of interest to note that Berlioz, in his Classification of Birds, treated these six groups consecutively (pages 930 to 974, in Grassé, 1950).

Aprocta spp. are known from the Lariformes, the Charadriiformes, the Ralliformes (Burrhinidae and Otididae), the Falconiformes (similarly grouped by Berlioz, p. 884-929), and the vast group of Passeriformes.

The Australian species which have been studied herein are assigned to the two genera *Aprocta* and *Lissonema*.

Aprocta boulengeri n.sp.

(Figs. 3, 4)

Material

Strepera graculina Shaw (Cracticidae) from Warwick, Qd., from head and nasal cavities, holotype ♀, allotype ♂ (SAM V2098 and V2099) and 1 entire ♀ and 2 broken ♂ (AHC 5839).

Morphology

The morphology is shown in Figures 3 and 4. Unpaired portion of ovejector short and simple.

Dimensions

Holotype ♀: length 50 μm; width 920 μm; cephalic papillae form area 110 μm (laterally) by 70 μm (dorsoventrally); nerve ring and vulva respectively 175 μm and 940 μm from head; oesophagus 1060 μm long, with muscular part 215 μm long; tail length 385 μm, egg 58 μm by 32 μm.

Allotype ♂: length 25.6 mm, diameter 600 μm; cephalic papillae area 110 μm x 55 μm; buccal capsule 20 μm long; nerve ring and excretory pore 205 μm and 305 μm from head; oesophagus 800 μm long with muscular part 190 μm; tail length 320 μm; right and left spicules 400 μm and 440 μm long, 22 μm wide.

Other entire female: body length 37 mm, diameter 910 μm; cephalic papillae on area 88 μm x 57 μm; buccal capsule 38 μm long; nerve ring, excretory pore and vulva respectively 220 μm, 310 μm and 680 μm from head; oesophagus 965 μm long, with muscular part 200 μm; unpaired part of ovejector 600 μm long; tail length 240 μm; larvae 190 and 205 μm long, 11 μm wide.

Discussion

This species is easily differentiated by the following characters: presence of a median subterminal papilla on the male tail, spicules 400-440 μm in length, with tricuspid distal extremities, vulva slightly in front of the oesophago-intestinal junction, anus of the female not terminal. This is proposed as a new species *A. boulengeri*.

Aprocta bakeri n.sp.

(Fig. 5)

Material

Corvus orru Bonaparte (Corvidae) from Emu Vale, near Warwick, Qd., from nasal cavity: holotype ♂ (SAM V21000).

* The eggs measure only 45μm x 25 μm, but their concave form indicates that they are not embryonated.

† Among species from Cuculiformes, those from *Centropus* are unusual in having a long oesophagus (5-7 mm), clearly divided.

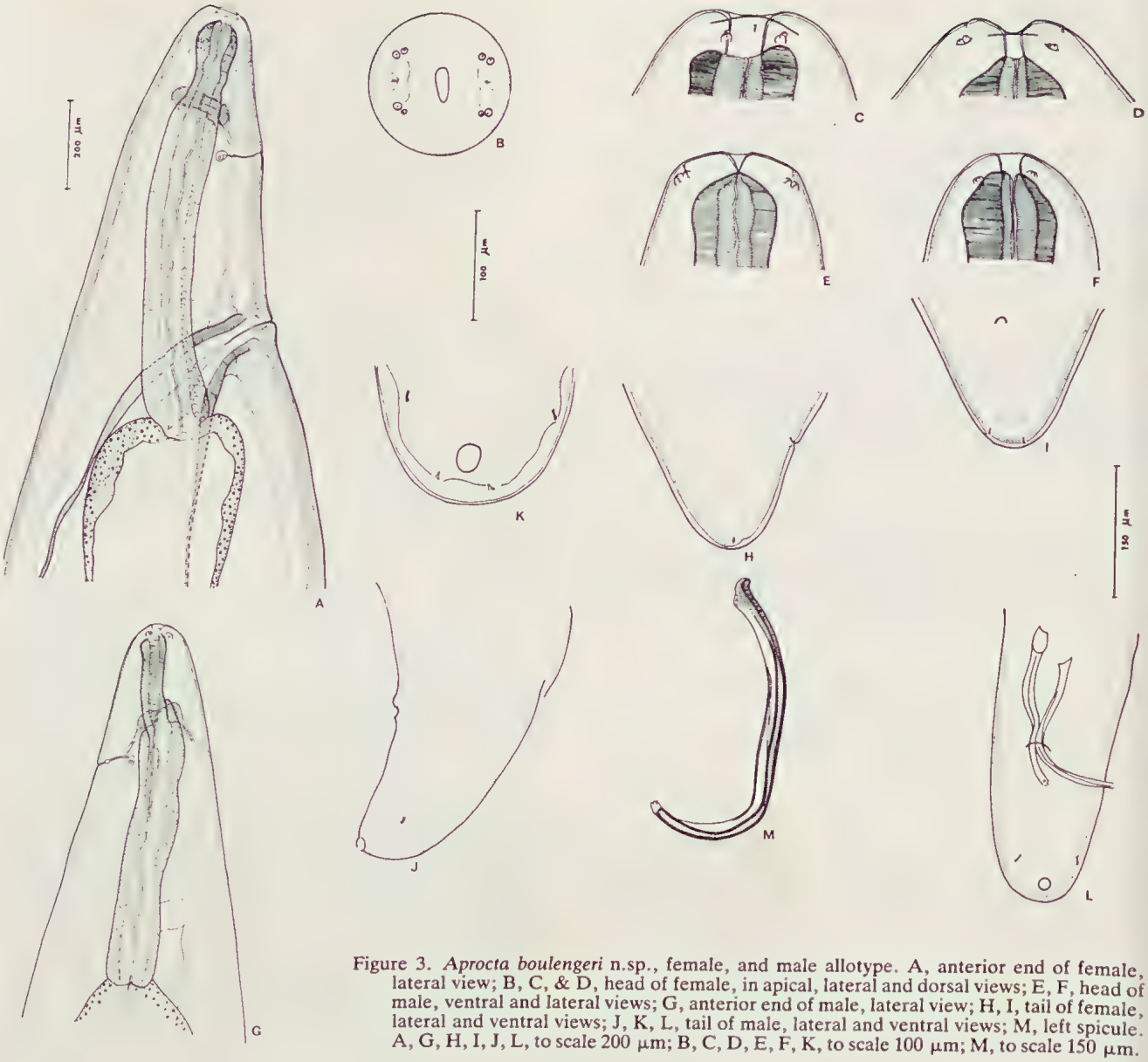

Figure 3. *Aprocta boulengeri* n.sp., female, and male allotype. A, anterior end of female, lateral view; B, C, & D, head of female, in apical, lateral and dorsal views; E, F, head of male, ventral and lateral views; G, anterior end of male, lateral view; H, I, tail of female, lateral and ventral views; J, K, L, tail of male, lateral and ventral views; M, left spicule. A, G, H, I, J, L, to scale 200 µm; B, C, D, E, F, K, to scale 100 µm; M, to scale 150 µm.

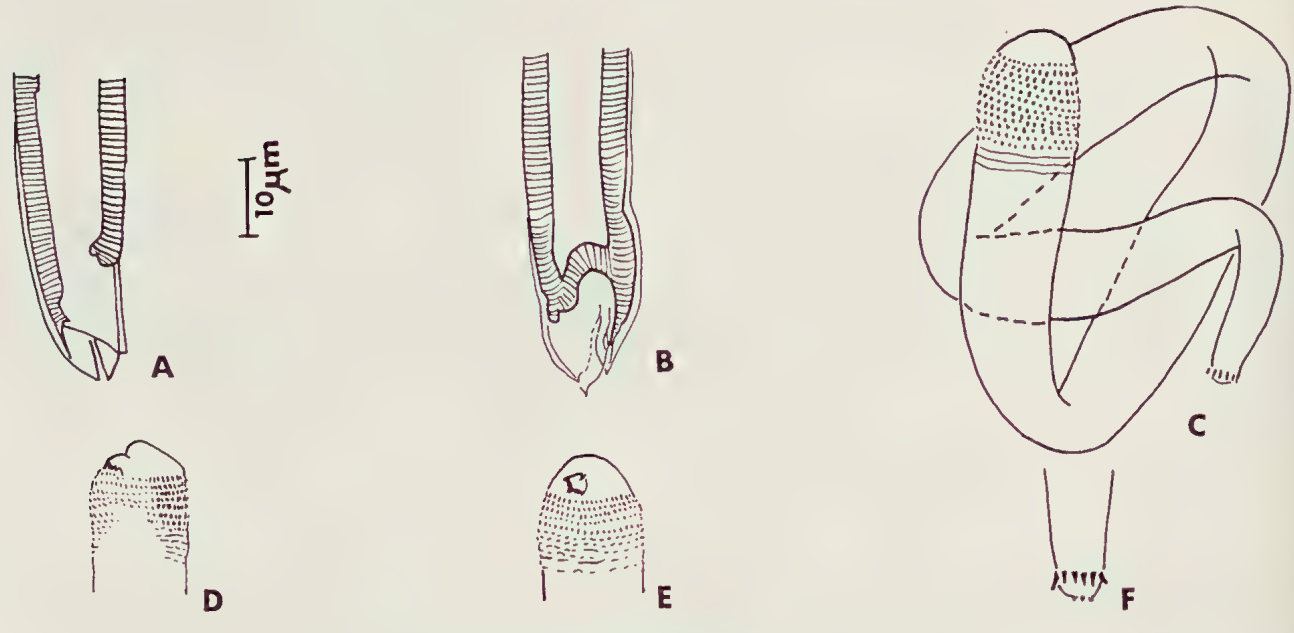

Figure 4. *Aprocta boulengeri* n.sp. (cont.) A, and B, tips of left and right spicules, ventral views; C, larva; D, E, head of larvae, with hooks seen in profile and full face; F, tip of tail of larva. A-E, to scale 10 µm; F, free-hand.

Description

Morphology is shown in Figure 5. Triangular buccal cavity. Cloaca opening on conspicuous protuberance.

Dimensions

Body length 29 mm, diameter 550 μm; buccal capsule 40 μm long; nerve ring 140 μm from head; left and right spicules respectively 390 μm and 330 μm long; tail length 260 μm.

Discussion

The bifid extremity of the testis in these specimens resembles that of *Aprocta laevicutis* from *Cyornis banyumas whitei* but is distinguished from this species by the larger body size and by the spicule length (390 and 330 μm instead of 210-170 μm). It is also distinguished from all other *Aprocta* spp. by a voluminous protuberance bearing the cloacal opening. It is proposed as a new species, *A. bakeri*, dedicated to our Canadian colleague, Michael Baker.

Lissonema sp.

(Fig. 6)

Material

From *Ninox novaeseelandiae* Gmelin (Strigidae) from Berrimah, N.T., 1♀ (AHC 6261).

Description

The morphology is shown in Fig. 6. Mouth and buccal capsule narrower dorso-ventrally than laterally; buccal capsule stoutly built, of two parts—anteriorly, a thickening of the cephalic cuticle,

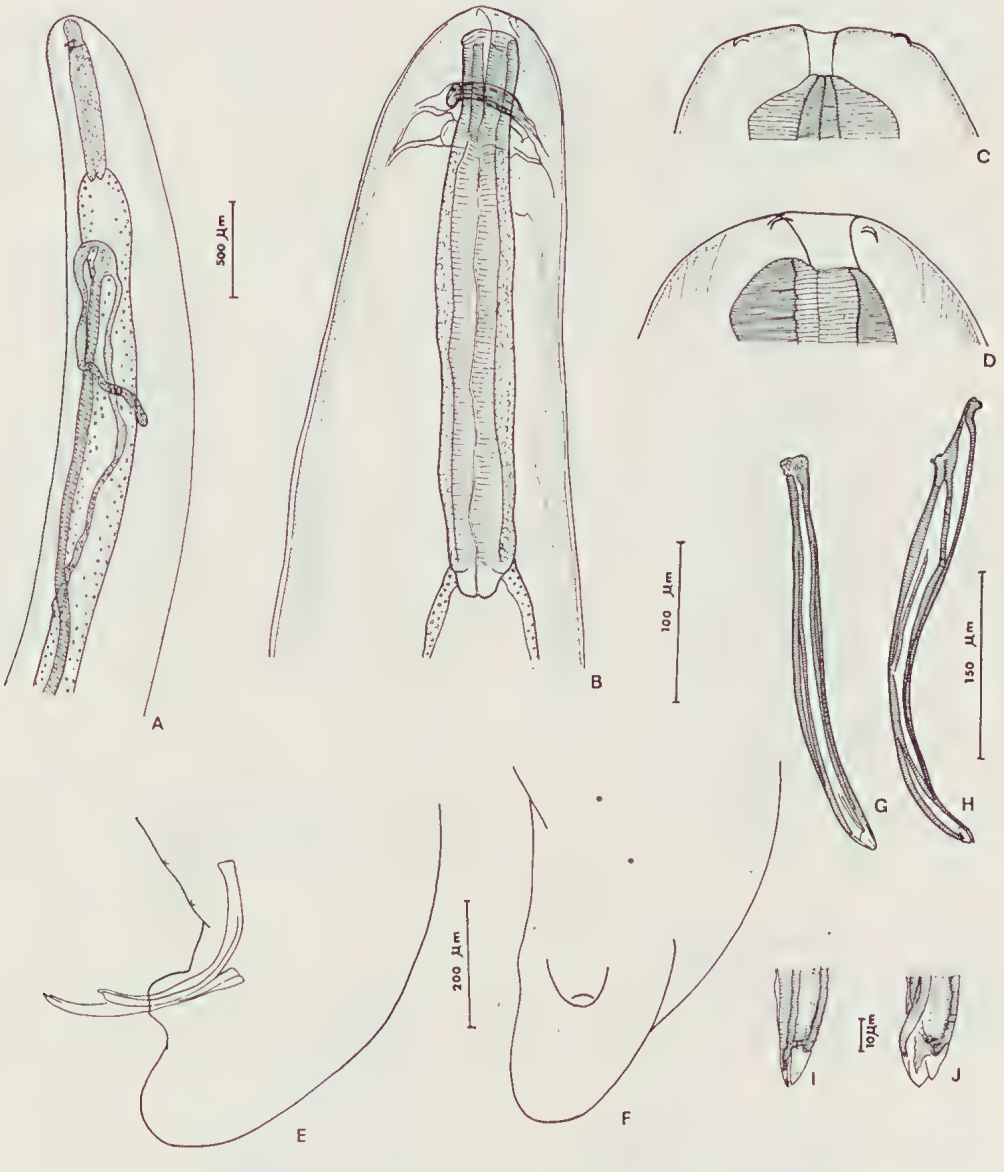

Figure 5. *Aprocta bakeri* n.sp., holotype male. A, anterior end; B, oesophageal region, lateral view; C, D, head in dorso-ventral and lateral views; E, F, tail, in lateral and subventral views; G, H, right and left spicules, ventral views; I, J, distal extremities of same spicules; A, to scale 500 μm; B, E, F, to scale 200 μm; C, D, to scale 100 μm; G, H, to scale 150 μm; I, J, to scale 10 μm. v, vulva.

posteriorly, a pre-oesophageal thickening, poorly defined externally, and thicker laterally. Base of buccal cavity formed by the three prominent and sclerotised oesophageal lobes. The cuticular 'scales' are irregularly distributed over the body length, but the lateral fields are smooth. Unpaired portion of ovejector long and complex (Fig. 6 J).

Measurements

Body length 34 mm, diameter 590 μm; buccal cavity 22 μm long; nerve ring, excretory pore and deirids at 155 μm, 242 μm and 270 μm from head; oesophagus 1200 μm long, with muscular part 230 μm long; vulva 700 μm from head; unpaired part of ovejector 4660 μm long; tail length 95 μm; cuticular scales on body 22 μm long, 13 μm wide, commencing at 1150 μm from head and ending 550 μm from posterior end of body. Eggs 66 μm x 38 μm; larva 415 μm long, 13.5 μm in diameter.

Discussion

Among the species of this genus in which there is a buccal capsule, *L. sicki*, *L. nepalensis*, *L. ungriai* and *L. coraciae*—only the last named agrees with the Australian specimens in having 'scales' on the body, but the shape and arrangement of these was not exactly described. The dimensions of the female are very close, except the length, which is only half that of the Australian specimens. In view of this, and of the different geographical range, no specific identification is made.

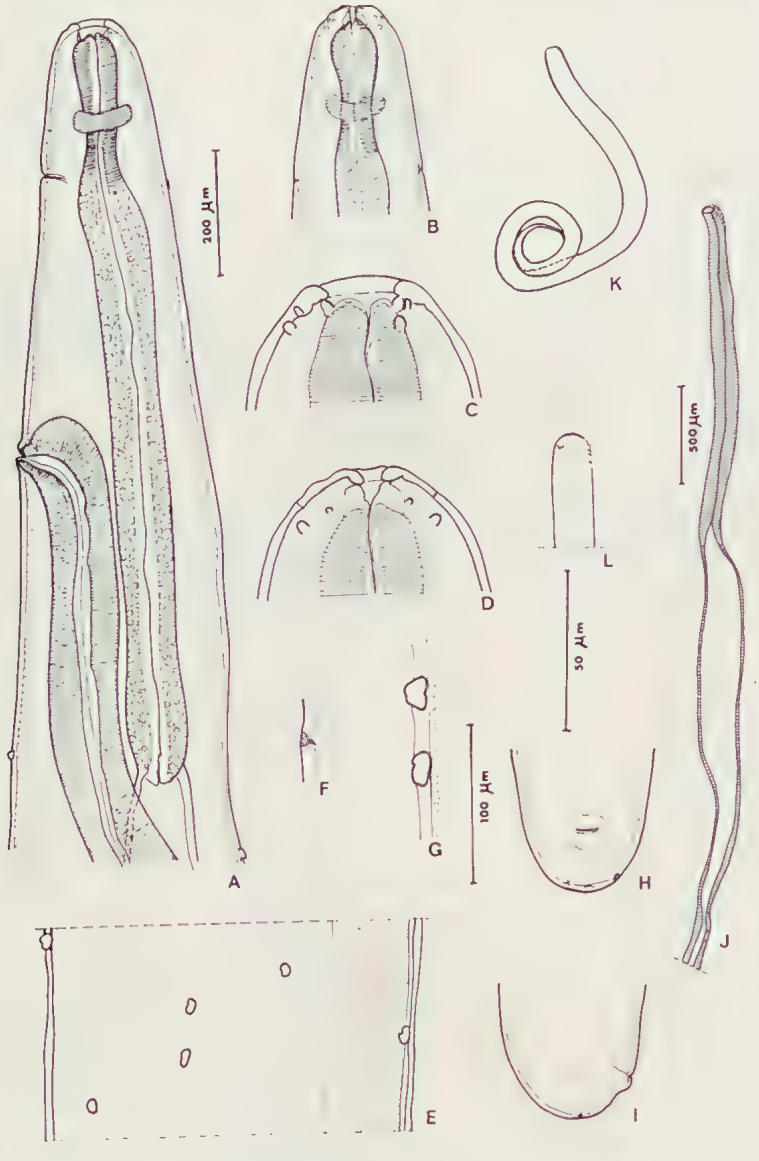

Figure 6. *Lissonema* sp., female. A, oesophageal region, lateral view; B, anterior end, median view; C, D, head, lateral and median views; E, cuticular ornamentation in region of mid-body, in submedian view; F, deirid, lateral view; G, cuticular scale in lateral view; H, I, tail, ventral and lateral views; J, ovejector, distal part; K, larva; L, head of larva; A, B, E, H, I, to scale 200 μm; C, D, F, G, K, to scale 100 μm; J, to scale, 500 μm; L, to scale 50 μm.

II. Diplotriaenoidea—Dicheilonematinae

Genus Serratospiculum Skrjabin

The genus *Serratospiculum* contains *(a)* species with small spicules (left spicules 600-700 μm, right spicule 300-350 μm), which may be considered as grouped about *S. guttatum* and *(b)* species with large spicules (left spicule 1100-1300 μm, right spicule 350-500 μm) grouped about *S. tendo.*

(a) Species with small spicules

S. guttatum (Schneider, 1866): the most characteristic feature of this species is the cuticular ornamentation of the female body, in the form of large bosses, well described by Schneider. The species is recorded in Australia from *Falco berigora* by Schneider, 1866, from *F. longipennis* and *F. peregrinus* (Syn. *F. melanogenys)* by Johnston & Mawson, 1941, and in the present paper.

Species grouped with *S. guttatum* may have (i) smooth or (ii) ornamented cuticle.

(i) With smooth cuticle:

S. chungi Hoeppli & Hšu, 1929, from *Falco* sp., China.

S. congolensis Vuylsteke, 1957, from *Butastur rufipennis* (Sund.) from equatorial Africa*. This species is distinguished from *S. chungi* by the structure of the right spicule: the oblique crests are present on the distal third of the spicule, not on the distal half.

S. seurati n.sp. (syn. *Filaria attenuata* Rud., 1819 *sensu* Seurat, 1915) from various Falconidae, from North Africa, is close to *S. chungi* but can be distinguished by the cephalic structure—the epaulettes concave with regard to the dorso-ventral axis, and not rectilinear (Fig. 18 of Hoeppli & Hšu, 1929), relatively narrower—(30 μm wide by 100 μm long in *S. seurati,* 50 μm wide by 120 μm long in *S. chungi).*

(ii) With cuticular ornamentation:

S. turkestanicum Skrjabin, 1916 (type species of the genus), from *F. tinnunculus* L. from Central Asia, is well distinguished by the type of cuticular ornamentation, consisting of points curved backwards.

S. kwangsiensis Hšu, 1963, from *F. columbarius insignis* (Clark) from China, is close to *S. guttatum* in the structure of the head and the presence of rounded bosses on the cuticle of the female, but these bosses continue to the level of the anus in this species but only to 1 mm from the posterior extremity in *S. guttatum;* also, the distal half of the spicule is particularly delicate.

The filarial worms described by Li (1933) from *F. columbarius* (syn. *Hypotriorchis aesolon),* from China, as *S. turkestanicum* seems from the character of the female cuticle, to be *S. kwangsiensis.*

(b) Species with large spicules

This group contains three species, all without cuticular ornamentation in the female:

S. tendo Nitzsch, 1819†, the species is parasitic in *F. peregrinus* in Europe (Nitzsch *in* Rudolphi, 1819; Dujardin, 1845; Yorke & Maplestone, 1926) and in Australia (material described here and, as pointed out by Sonin (1968), some parts of the material seen by Johnston & Mawson, 1941, and noted as *S. guttatum*). The species is also found in other falcons, and in other parts of the Old World.

S. thoracis Tubangui, 1934, from *Falco ernesti* in the Philippines; the dimensions of this species are similar to those of *S. tendo.*

S. lii Ezzat & Tadros, 1958, from *F. peregrinus callidus* from Belgian Congo. In this species the measurements resemble those of the two preceding species. The *area rugosa* and the detailed structure of the spicules have not been described, and as pointed out by Sonin (1968), it is possible that these three species are synonymous.

It appears that there are more species of *Serratospiculum* than allowed by Sonin (1968). It also appears that *S. guttatum* is found only in Australia, and that references to its presence in other parts of the world are erroneous.

The Australian material from falcons (Falconidae) permits the redescription of two species, *Serratospiculum guttatum* (Schneider, 1866) and *S. tendo* (Nitzsch, 1819). Comparison of the Australian material with specimens in MNHN has led to the identification of a new species, *S. seurati.*

Serratospiculum guttatum (Schneider, 1866)

(Fig. 7)

Material

From *Falco longipennis* Swainson, from Fleurieu Peninsula and Yorke Peninsula, South Australia. 9♂, 5 anterior and 2 posterior ends of ♂, 7♀, 4 anterior and 5 posterior ends ♀ (AHC 6279); 2♂ and 2♀ (MNHN, 193 HD).

From *Falco peregrinus* Tunstall, from Mallala, S.A. 3♂, 1 posterior end ♂, (AHC 6280).

Description

The morphology is shown in Fig. 7. The shape of the head is the same in all specimens . . . broader on lateral axis, epaulettes twice as long as wide (80 μm

* The apical view shown in Fig. 36 appears to be in error; the piece of the head shown is probably seen upside down, from the posterior aspect.

† Railliet & Henry (1916) have resolved clearly the question of the nomenclature of this species.

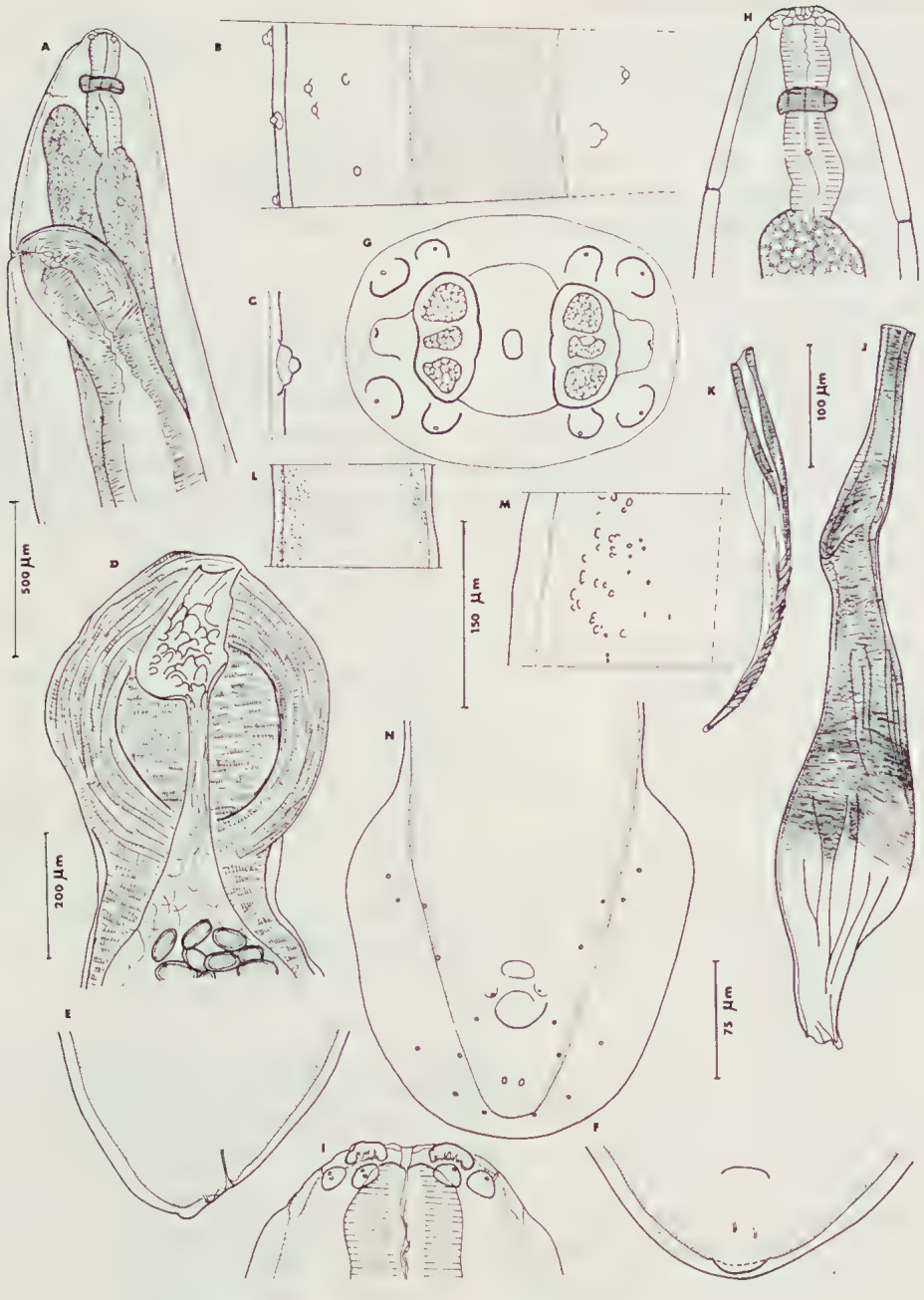

Figure 7. *Serratospiculum guttatum* A-G, female H-N male, A, anterior end, lateral view; B, cuticular ornamentation in mid-body, lateral view; C, the same, detail of one boss; D, distal end of ovejector; E, F, tail, in lateral and ventral view; G, head, apical view; H, anterior end, ventral view; I, head, median view; J, K, left and right spicules; L, *area rugosa*, ventral view; M, the same, in detail; N, tail, ventral view; A, scale 500 µm; B, D, H, to scale 200 µm; C, E, F, to scale 150 µm; G, I, L, M, N, to scale 75 µm.

by 40 µm) and in apical view, convex with regard to the dorso-ventral axis. Cuticular ornamentation present only in the female. *Area rugosa* forms two latero-ventral bands of low cuticular protuberances.

Dimensions

Three females: length 127, 150 and 140 µm, width 700, 790, and 600 µm; nerve ring at 175, 180, and 240 µm from head; excretory pore at 205, ?, and 240 µm from head; deirids at 250, 220, and 510 µm from head; muscular oesophagus 420 µm long, and with glandular part 13 mm long (measured on one of the females dissected); vulva at 740, 600, and 1050 µm from head; length of unpaired part of ovejector 2150 µm (in female dissected); tail 90-110 µm long; embryonated eggs 52 by 30 µm; cuticular ornamentation starts at 3 mm from the head and ends at 1 mm from the posterior end.

Two males: length 72 and 93 mm, width 480, 560 µm; nerve ring and excretory pore 150, 230 µm from head (measured on one male); deirids at 280 and 340 µm, 212 and 275 µm from head; muscular oesophagus 320, 365 µm long, length of glandular

oesophagus not determined; tail length 80, 82 μm; length of left spicules 650, 670 μm, of right spicules 350, 360 μm; *area rugosa* lying from 5.4 mm to 450 μm from the posterior end (measured on one male).

Serratospiculum tendo (Nitzsch, 1819)

(Fig. 8)

Material

From *Falco peregrinus* Tunstall, from Port Augusta, S.A. 1♀, 1♂ (AHC 6273).

This material has been compared with MNHN 510 JJ collected in France from the same host species; this consists of one anterior end and two posterior ends of ♂ and the anterior and posterior ends of 1♀.

Description

The morphology of the two lots of material is similar, and is shown in Figure 8. The cephalic structure is constant: rounded head, epaulette 3-4 times as long as wide (110 μm by 30 μm), concave

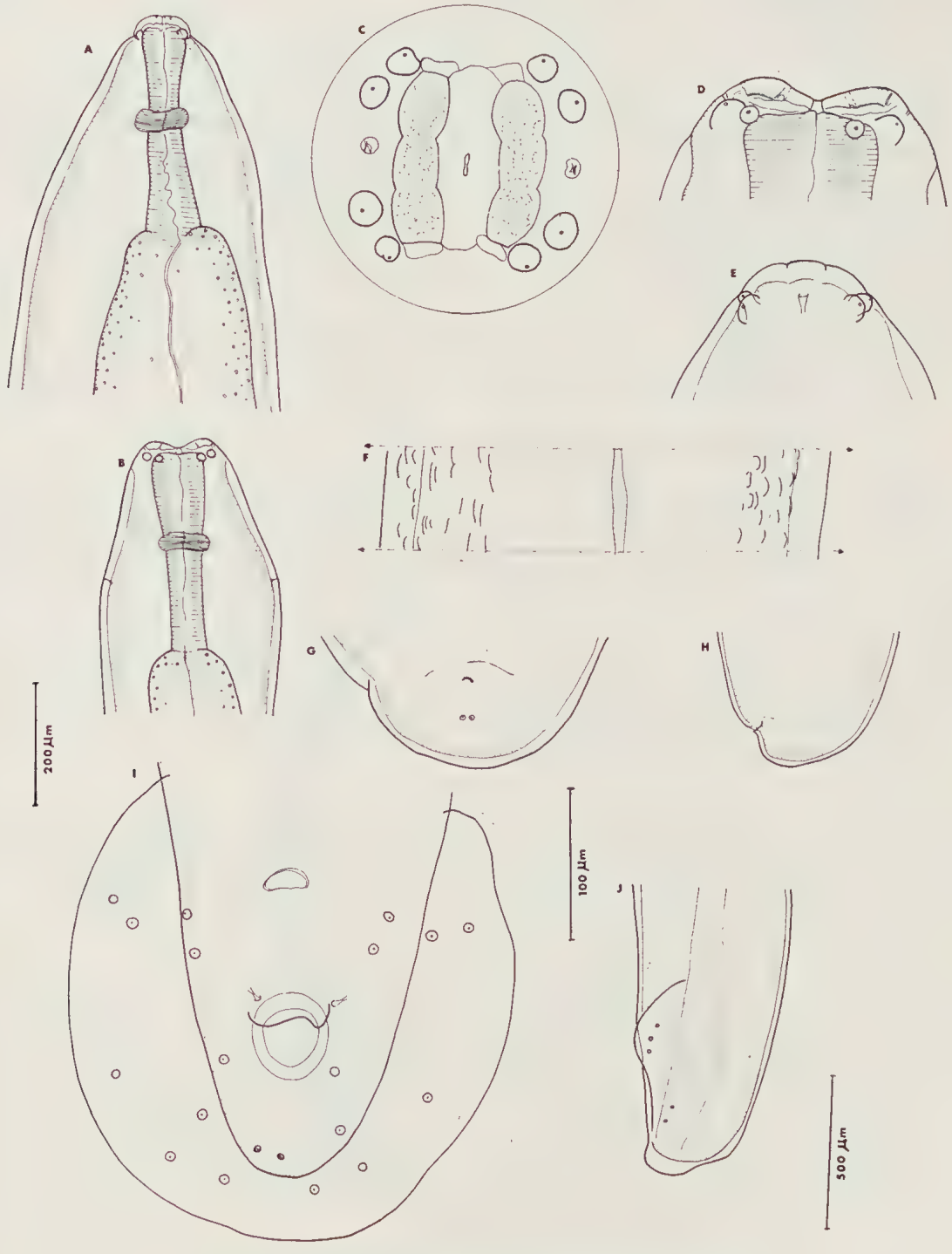

Figure 8. *Serratospiculum tendo*. A, anterior end of female, lateral view; B, anterior end of male, median view; C, head of female, apical view; D, E, head of male, median and lateral views; F, male, *area rugosa*, ventral view, G, H, female, tail, ventral and lateral views; I, J, tail of male, ventral and lateral views; F and J, Australian material, other figures French material. A, B, G, J, to scale 200 μm; C, D, E, F, I, to scale 100 μm; H, to scale 500 μm.

with regard to the dorso-ventral axis, and prolonged by 4 small additional swellings. *Area rugosa* in form of two ventro-lateral bands of small longitudinal cuticular wrinkles. Spicules not drawn, as studied by Bain & Vassiliades (1969).

Measurements of Australian specimens

Female: length of body 190 mm, width 825 μm; nerve ring and deirids 300 μm and 210-220 μm from head; length of oesophagus 19.7 mm, of muscular part 600 μm; vulva 1650 μm from head; tail 100 μm long.

Male: length of body 148 mm, width 410 μm; nerve ring and deirids 200 μm and 305-310 μm from head; length of oesophagus 11 mm, of muscular part 600 μm; length of left spicule 1120 μm, of right 505 μm; tail 130 μm long; *area rugosa* extends from 4650 μm-600 μm from the caudal extremity.

Measurements of specimens from France

In female, vulva 1 mm from the head, tail 140 μm long. In male nerve ring and deirids 165 μm and 230 μm from head; length of left spicule 1150 μm, and 1120 μm, of right spicules 510 μm and 500 μm; tail 145 and 110 μm.

Serratospiculum seurati n.sp.

(Fig. 9)

Syn. *Filaria attenuatum* Rudolphi, 1819 *sensu* Seurat, 1915.

Material

Specimens studied by Seurat, 1915, and determined as '*Filaria attenuata* Rud., 1819 (= *F. guttatum* Schneider, 1866)'. This material, now in the MNHN, Paris, was taken from *Falco biarmicus erlangeri* Kleinschm at Biskra, North Africa; it comprises 2♂ of which one is in two pieces, 1

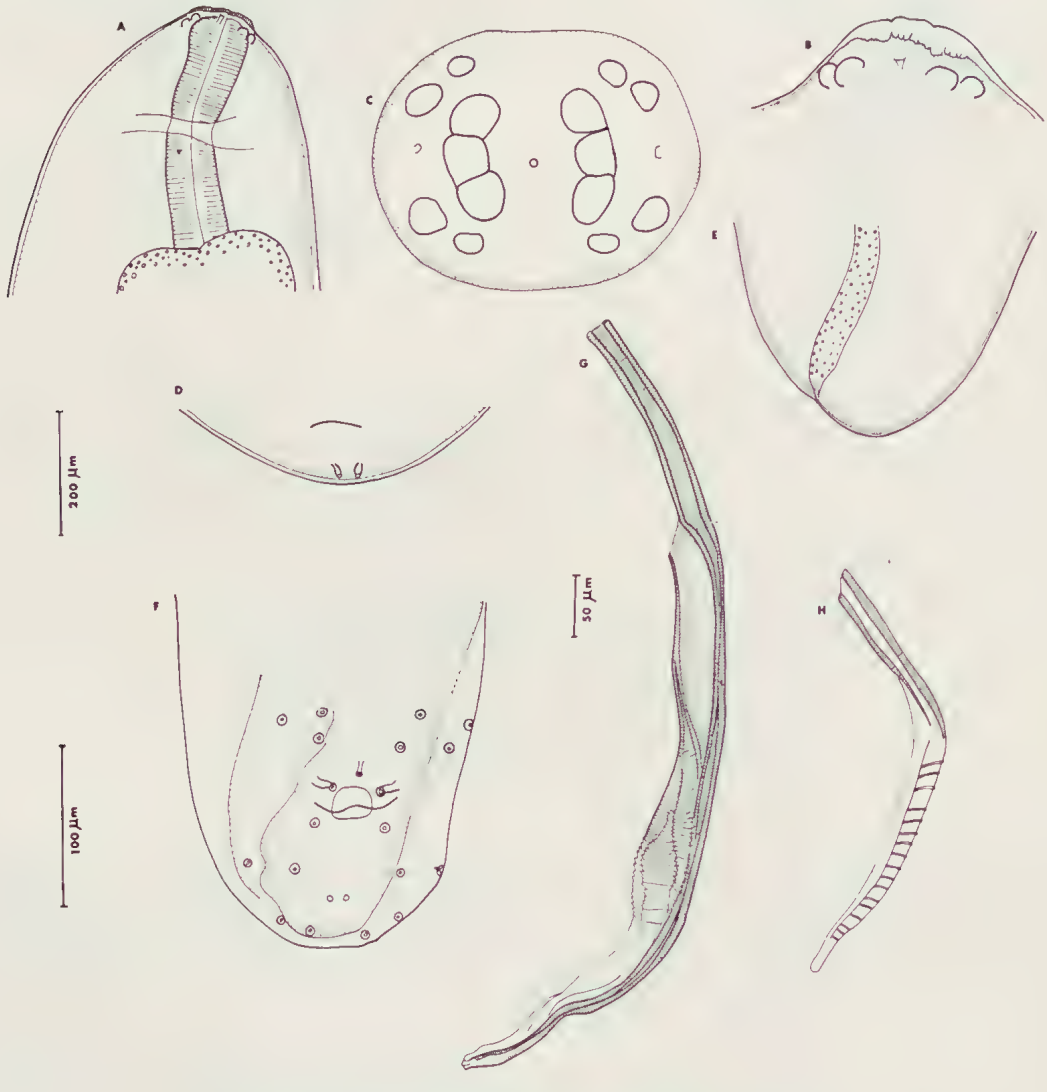

Figure 9. *Serratospiculum seurati* n.sp. A, anterior end of female, lateral view; B, head of holotype female, lateral view; C, head of female, apical view; D, E, tail of holotype female, ventral and lateral views; F, tail of male, subventral view; G, H, left and right spicules, lateral view. A, E, to scale 200 μm; B, C, D, F, H, to scale 100 μm; G, to scale 50 μm.

anterior end ♂, 2♀ and 2 posterior ends ♀. 1 entire ♀ and 1 entire ♂ were chosen as holotype and allotype respectively (MNHN 110 EJ).

(2) specimens collected by Dollfus (MNHN 114 A) in 1914 from *Falco* sp., from Rabat, Morocco, labelled *S. guttatum* (Schneider, 1866): consisting of numerous pieces including 2 anterior and 4 posterior ends of ♀, 3 anterior and 1 posterior ends ♂.

Morphology

The general morphology, well described by Seurat, is complemented by Figure 8. The structure of the head, in both lots of material, is similar. The position of the vulva is somewhat variable (450-1000 μm from head). An *area rugosa* appears to be absent. The right spicule bears low crests, obliquely placed.

Measurements

Holotype ♀: length of body 135 mm, width 770 μm; vulva 470 μm from head; tail length 40 μm. Specimen not sufficiently clear for other measurements.

Allotype ♂: length of body 42 mm, width 480 μm; nerve ring and deirids 130 μm and 230 μm from head; length of oesophagus 10 mm, of its muscular part 270 μm; left spicule and right spicules respectively 775 μm and 300 μm; tail length 110 μm.

From MNHN 114 A (2 pieces): length unknown; width 500 μm; nerve ring 170 μm from head; muscular oesophagus 310 μm; left and right spicules respectively 650 μm and 350 μm, tail length 110 μm.

Diplotriaenoidea: Diplotriaenaidae

Diplotriaena spratti n.sp.

(Fig. 10)

Material

From *Oreoica gutturalis* Vigors & Horsfield (Muscicapidae) from the Petermann Ranges, N.T. Holotype ♀ and allotype ♂ (SAM, V2101 and V2102 respectively); 6♀, 9♂, and numerous pieces of ends of ♀ and 1 posterior end ♂ (AHC 6272); 1♀ and 2♂ paratypes (MNHN, Paris, 204 HD).

Description

Morphological features are shown in Figure 10.

Measurements

Holotype ♀: length of body 68 mm, width 700 μm; nerve ring 240 μm from head; tridents 150 μm and 172 μm long; length of oesophagus 3720 μm, of muscular part 370 μm; vulva 500 μm from head, unpaired portion of ovejector 3300 μm long; tail length 110 μm; eggs, non-fertilized, 32 μm by 18 μm.

Paratype ♀s: body length 66-71 mm; in ♀ length 66 mm, width 500 μm; nerve ring and vulva 290 μm and 425 μm from head; trident 135 μm; oesophagus 4500 μm; eggs 45 μm by 35 μm.

Allotype ♂: body length 32 mm, width 400 μm; nerve ring 200 μm from head; muscular oesophagus 3850 μm long; tail 50 μm; left and right spicules respectively 4500 and 600 μm long.

Paratype ♂s: length of body 32-34 mm; of oesophagus 2600-3275 μm; left spicule 4200-6300 μm, right spicule 510-600 μm; in one male 32 mm long; body width 455 μm, nerve ring 230 μm from head; tridents 125 μm; length of oesophagus 3400 μm, of tail 55 μm; left spicule 4200 μm long, with calamus 650 μm, right spicule 550 μm.

Discussion

This species can be compared with the others of the genus in which the left spicule is longer than 2000 μm. These are: *D. bhamoensis* (Parona, 1889)* redescribed by Anderson (1959) from Sturnidae and Turdidae in Asia, has the trident not pointed but concave at the apex, a much longer oesophagus (8-12 mm instead of 2.6-6.3 mm), left spicule not exceeding 2600 μm, and the right spicule spiralled about a strongly curved axis, whereas in the Australian specimens the axis is almost straight.

In *D. ecaudata* (Oerley, 1882), from Sturnidae in Africa the trident is concave at the tip, the left spicule is not longer than 2800 μm, and the axis of the right spicule has three strong bends.

D. tricuspis (Fedtschenko, 1874) sensu Singh, 1949, is, as pointed out by Anderson (1959), a mistaken determination. It is clear from Singh's paper that though the female is a *Diplotriaena* sp., the male (Fig. 27) is a *Hamatospiculum* sp. The Australian species is proposed as *D. spratti* n.sp., named after our colleague David Spratt. The species is characterised by the pointed apex of the trident, the long left spicule (over 4000 μm) and the right spicule spiralled around an almost straight axis.

* *B. buckleyi* Fotedar & Kaw, 1965, and *D. mirzapurensis* Soota & Chaturvedi, 1967, both parasites of *Acridotheres tristis*, have no morphological difference from *D. bhamoensis*, and are regarded as synonyms of this species.

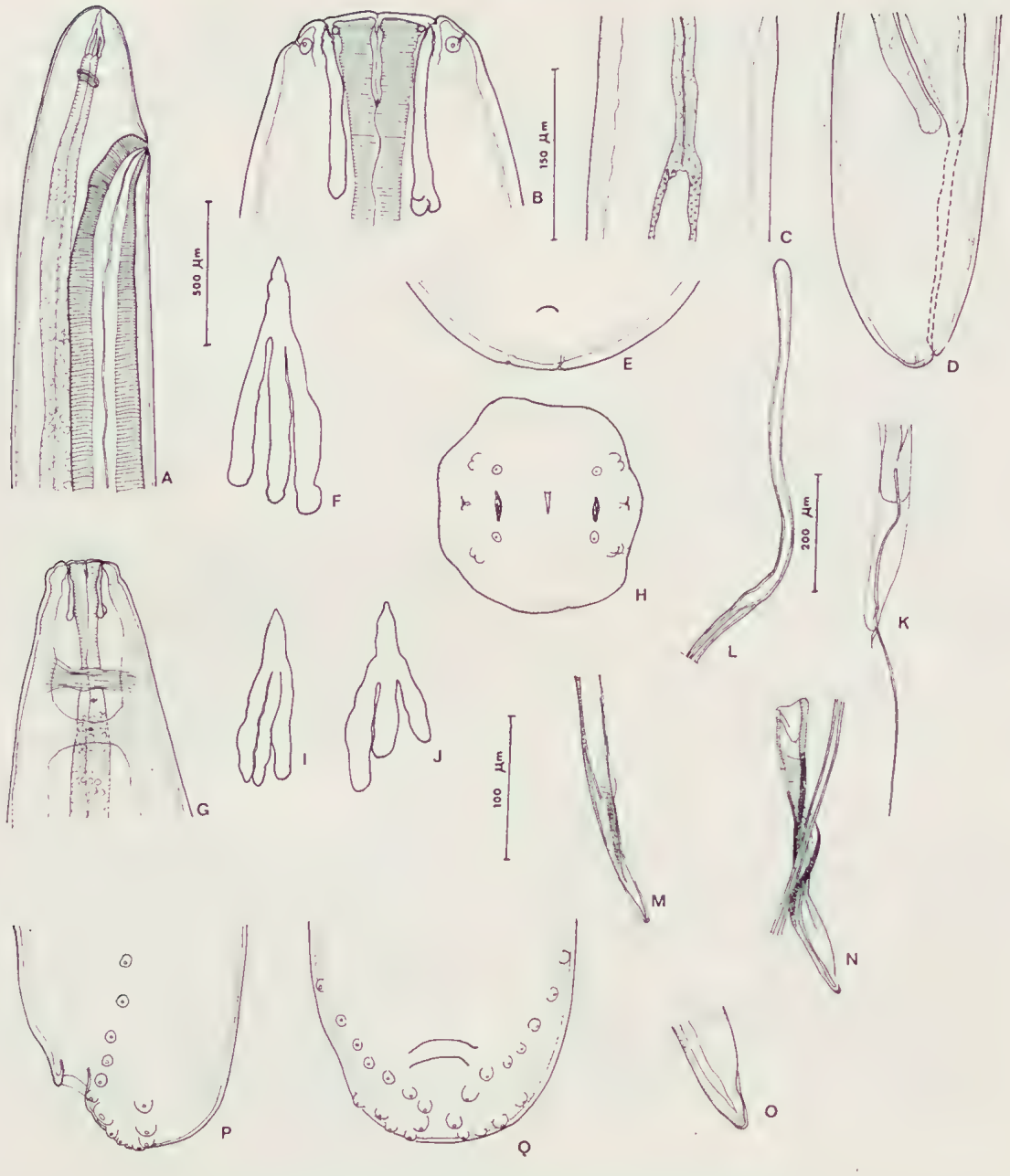

Figure 10. *Diplotriaena spratti* n.sp. A, anterior end of holotype female, lateral view; B, head of holotype female, median view; C, junction of oesophagus and intestine, paratype female; D, E, tail of paratype female, lateral and ventral views; F, trident of holotype female; G, to Q, male: G, anterior end, ventral view; H, head, apical view; I, J, tridents of two specimens; K, posterior end, lateral view; L, M, the two extremities of the left spicule; N, right spicule and part of the left spicule; O, distal end of right spicule, ventral view; P, Q, tail in lateral and ventral views. A, D, to scale 500 µm; B, to scale 150 µm; C, E, G, L, N, to scale 200 µm; F, I, J, M, O, P, Q, to scale 100 µm.

Diplotriaena beveridgei n.sp.

(Fig. 11)

Material

From *Corvus orru* Bonaparte (Corvidae) from Emu Vale, near Warwick Qd: Holotype ♀ (SAM V 2103) and posterior end (10 mm) of allotype ♂ (SAM V 2104); 2♀, 2 anterior and 3 posterior ends ♀ (AHC 6276).

Description

Morphological features are shown in Figure 11.

Measurements

Holotype ♀: body length 102 mm, width 1400 µm, nerve ring 450 µm from head; trident 285 µm long; oesophagus 9500 µm long, its muscular part 575 µm; vulva 630 µm from head; eggs 50 x 35 µm; tail 200 µm long.

Allotype ♂: the piece is 1.11 mm wide; tail 10 µm long; left spicule 1355 µm long (calamus 250 µm); right 1075 µm.

Paratypes: one anterior end of ♀, 1400 µm wide, with nerve ring 390 µm from head, tridents 250 µm

Figure 11. *Diplotriaena beveridgei* n.sp. A-H, female; I-L, male. A, anterior end, lateral view; B, oesophago-intestinal junction; C, head, apical view; D, head, lateral view; E, F, trident and its apex; G, H, tail, ventral and lateral views; I, posterior end, ventral view; J, K, right and left spicules; L, tail, ventral view. A, B, G, H, to scale 500 µm; C, to scale 150 µm; D, E, J, K, to scale 200 µm; F, L, to scale 100 µm; I, to scale 1000 µm.

and 270 µm; oesophagus 8950 µm with muscular part 580 µm; vulva 650 µm from head, unpaired ovejector 2900 µm. One posterior end with tail 200 µm. Length of entire female 81 mm.

Discussion

The specimens differ from the other two *Diplotriaena* spp. from Australian Corvidae as follows:

In *D. alpha* Johnston & Mawson, 1940, the trident is smaller (120 µm instead of 250-285 µm) and oesophagus twice as long.

In *D. beta* Johnston & Mawson, 1940, considered by Anderson (1959) as a synonym of *D. flabellata* (Linstow, 1888) the oesophagus is very long, but the tridents shorter (190-200 µm), more massive, and with rounded apex, and the right spicule is a different shape.

The right spicule is bent in an 'L' similar to that of *D. delirae* Pinto & Noronha, 1970, from Tyrannidae in Brazil, however our material is distinguished from this species by the longer oesophagus, and the longer right spicule (1075 μm instead of 610 μm).

This material is therefore proposed as *D. beveridgei* n.sp., named after the collector, Dr Ian Beveridge. It is characterised by the large tridents, the long oesophagus (about 9 mm) and the 'L' shape of the right spicule.

Diplotriaena smithi n.sp.

(Fig. 12)

Material

5 collections from *Acanthogenys rufogularis* Gould: From The Bunkers, S. Aust.: 4 birds, as follows:

1. holotype ♀ (SAM V2105), allotype ♂ (SAM V2106)
   2♀, 1♂, pieces of ♀ and ♂ (AHC 6278)
   1♀, 1♂, posterior end 1♂ (MNHN, Paris 208 HD)
2. 1♀, 1♂ pieces of ♀ (AHC 6270)
3. 1♀, pieces of ♀ and ♂ (AHC 6268)
4. 4♀, 3♂, pieces of ♀ (AHC 6267)

From Wubin, W. Aust.: 6♀, 3♂ (AHC 6264); 3♀, 2♂ (MNHN, 208 HD).

Description

Morphological details are shown in Figure 12.

Dimensions

Holotype ♀: body length 50 mm, width 680 μm; trident length 220 μm; nerve ring and vulva 350 μm and 660 μm from head; length of oesophagus 4000 μm, of tail 45μm, of unpaired part of ovejector 2100 μm.

Allotype ♂: length of body 22 mm, width 530 μm; trident length 190 μm; nerve ring and excretory pore 310 μm and 350 μm from head; length of oesophagus 2850 μm, of tail 68 μm, of left spicule 800 μm, of right spicule 650 μm.

Paratype 3♀s: Length of body 35, 22, 39 mm; width 650, 610, 520 μm; tridents 205, 195, 190 μm; nerve ring 300, 290, 330 μm from head; length of oesophagus 2400, 2100 μm, damaged in 3rd; vulva 650, 730, 500 μm from head; tail length 40, 55, 55 μm.

Paratype ♂: body length 22 mm, width 520 μm, trident length 165 μm; nerve ring 280 μm from head; oesophagus 3400 μm long (muscular part 340 μm); length of tail 80 μm; of left spicule 785 μm, of right spicule 500 μm.

Variations observed among all the specimens: tridents 165-190 μm in males, 190-220 μm in females; vulva 480-730 μm from head; oesophagus 2000-3600 μm long in ♀; left spicule 730-850 μm, right spicule 500-680 μm. One male from AHC 6278 is teratological, with left and right spicules respectively 260 μm and 310 μm.

Discussion

D. zeta Johnston & Mawson, 1940, redescribed by Anderson (1959) was also taken from *Acanthogenys rufogularis;* the only female known is of similar dimensions to the present specimens, except that the trident is smaller (150 μm instead of 190-205 μm). Moreover, there are two grooves on the head of tridents in *D. zeta* not seen on any of the new specimens. These two differences, and the absence of a male of *D. zeta*, prevent the identification of the new material as *D. zeta*.

Five other species must be considered:

Two species have similar dimensions and spicule shape: *D. clelandi* (Johnston, 1912) from Cracticidae in Australia (male only known) and *D. kennedyi* Grewal, 1965, from Pycnonotidae from India. These two species are of doubtful status, as their morphology is imperfectly known, and it is impossible to compare our specimens with them.

The three other species in which the trident and spicules are similar to our specimens are distinguished as follows: in *D. pungens* (Schneider, 1866) from Turdidae in Asia, the oesophagus is very long (14500 μm in the ♀) and three pairs of papillae lie distinctly in front of the cloaca. In *D. flabellata* (Linstow, 1888), from Paradiseidae in the Aru Islands, the trident is more stoutly built, the body is particularly wide, the glandular oesophagus very long (6500-7500 μm in the female)—the left spicule strongly curved and the male tail rounded.

In *D. urocissoides* Anderson, 1959, from Corvidae in India, the head structure is characteristic ('buccal cavity surrounded by a clearly defined cuticular thickening often forming a plug,' Anderson, 1959) and the number of papillae is small.

It seems that the material described here is new, and the name *D. smithi* is proposed for it, in honour of our colleague I. Humphrey Smith. It is characterised by the large trident with blunt tip and without grooves, the oesophagus not very thick and not particularly long or short (2000-4000 μm), the spicules of medium length (730-850 μm and 500-600 μm) the tail of male rectangular in ventral view, with precloacal papillae few in number and situated close to the cloaca.

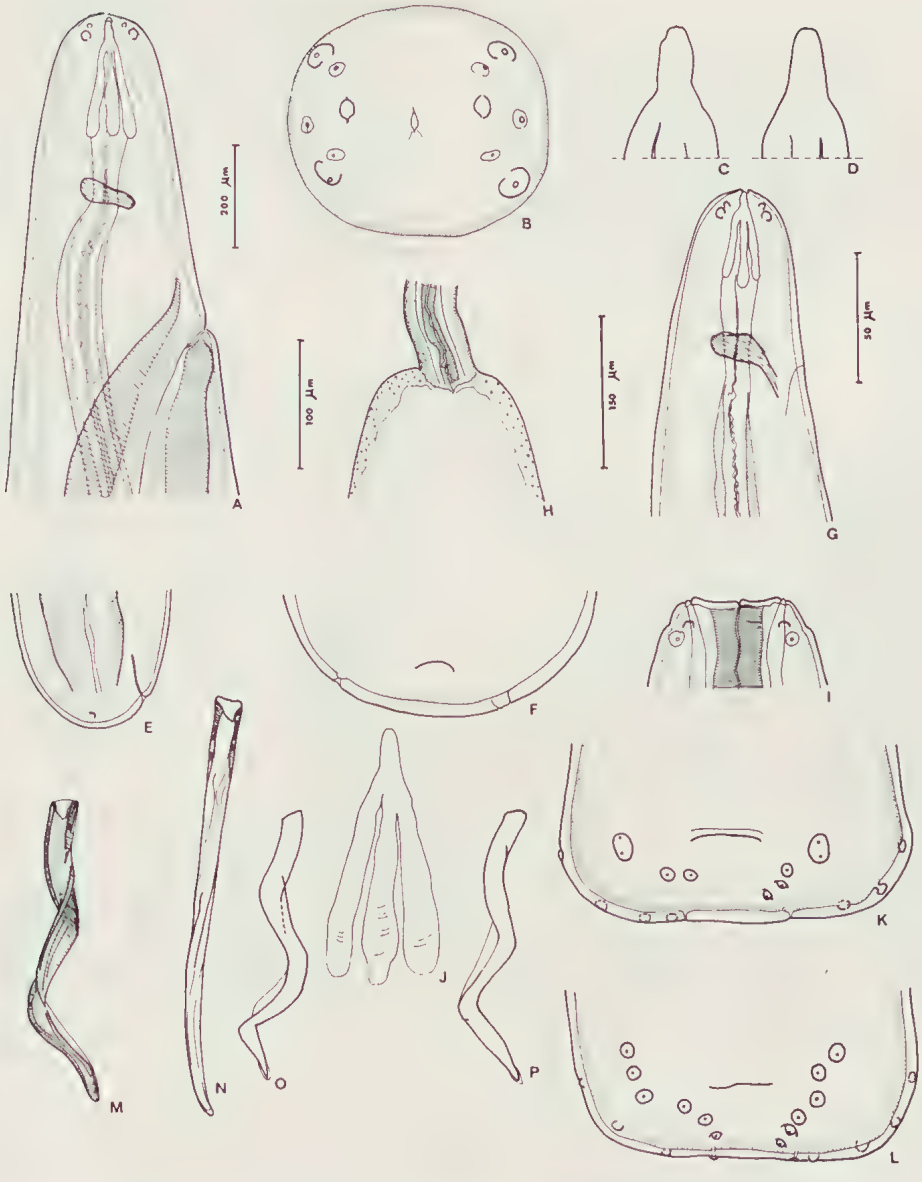

Figure 12. *Diplotriaena smithi* n.sp. A, anterior end of female holotype, lateral view; B, head of female paratype, apical view; C, D, same female, apex of tridents; E, F, tail of same female in lateral and ventral views; G, anterior end of male allotype, lateral view; H, same male, oesophago-intestinal junction; I, head of same male, lateral view; J, trident of male paratype; K, tail of male allotype, ventral view; M, N, male allotype, right and left spicules, ventral views; O, P, two other views of same right spicule; A, E, G, M, N, O, P, to scale 200 µm; B, H, F, J, K, L, to scale 100 µm; C, D, to scale 50 µm; I, to scale 150 µm.

Diplotriaena delta Johnston & Mawson, 1940

(Fig. 13 A-O)

Material

From *Amytornis goyderi* (Gould) (Maluridae), from the Simpson Desert, S. Aust.: 10♀, 2♂ (AHC 6274); 2♀ and 1♂ (MNHN 207 HD).

Description

Additional morphological details are given in Figure 13 A-O.

Dimensions

2♀: body length 70, 72 mm, width 460, 400 µm; tridents 115-120 µm and 100 µm; nerve ring 180, 190 µm from head; oesophagus length 1850, 2110 µm, its muscular part 330, 160 µm; vulva 525, 400 µm from head; tail length 70, 32 µm; eggs 46 x 29 µm. The extremes of the oesophagus are 1750 µm and 2400 µm, in females measuring respectively 62 mm and 70 mm.

2♂: body length 30, 28 mm, width 400, 380 µm; tridents 110, 120 µm; nerve ring 170, 160 µm from head; left spicule 950 µm long, (calamus 240 µm), and 1050 µm; right spicule 720, 630 µm long; tail 50, 60 µm.

Discussion

These specimens are identified as *D. delta*, described from *Malurus lamberti* (Maluridae) in Australia. This species, placed by Anderson (1959) as a synonym of *D. tridens* (Molin, 1858), was reinstated by Ogden (1965), who had specimens from *M. lamberti* from various parts of Australia.

D. delta is recognisable by the simultaneous presence of the following characters (taken from the new material and from Ogden): large body size (60-127 mm in female); tridents small (78-122 μm) with three small digitations at the tip; oesophagus of average size (1750-3900 μm in female, 1560-2600 μm in male), with glandular part thin or thick; left spicule 950-1140 μm, right spicule 620-730 μm, with triple twist; tail of male with two lateral swellings.

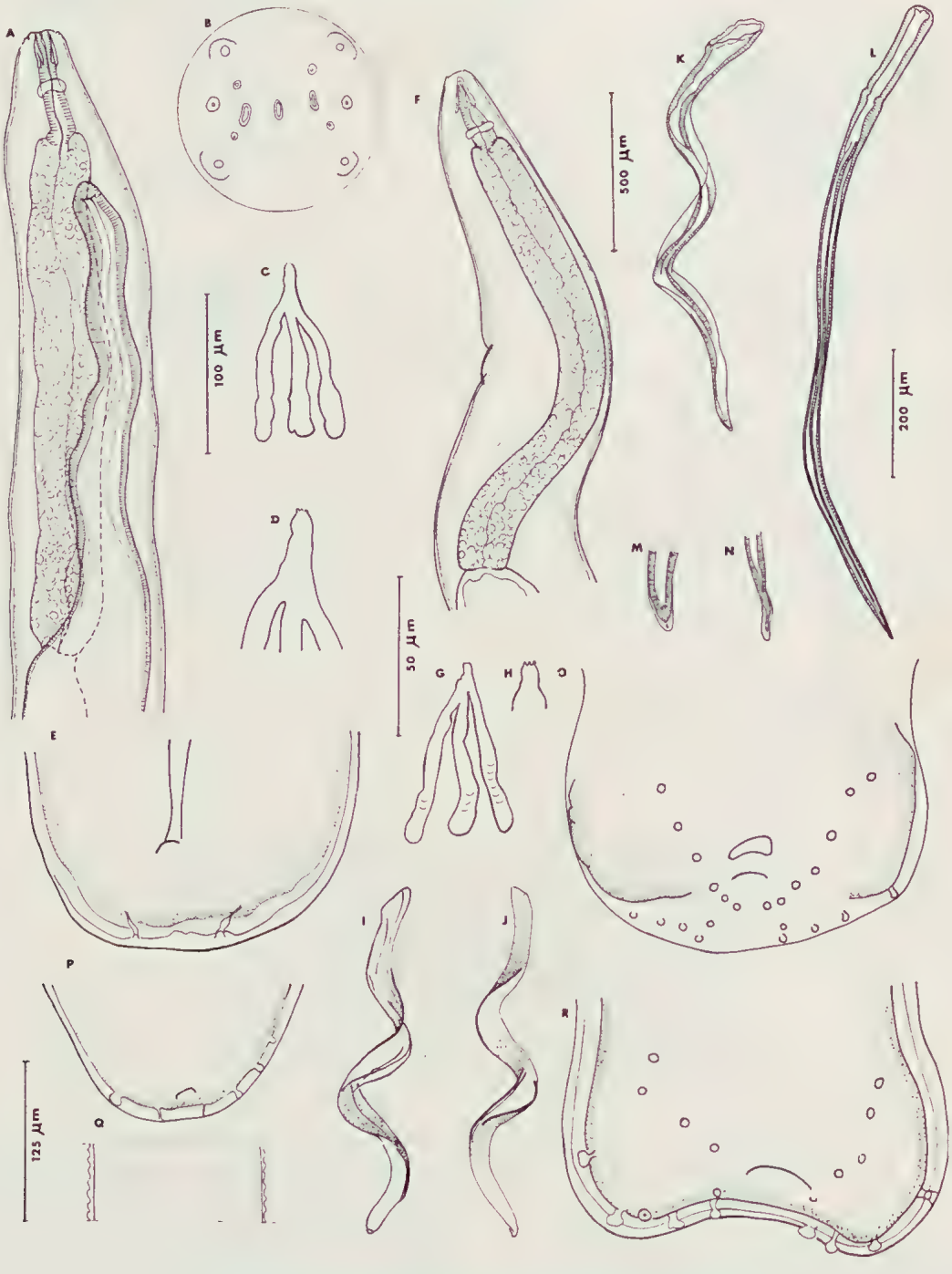

Figure 13. A-O, *Diplotriaena delta*, A-E, female: A, anterior end, subventral view; B, head, en face; C, D, trident and its apex; E, tail, ventral view; F-O, male; F, anterior end; G, H, trident and its apex; I, J, two views of right spicule; K, L, right and left spicules of another male, lateral view; M, N, tips of right and left spicules, ventral views; O, tail, ventral view.

P-R, *D. falconis*. P, tail of female, ventral view; Q, profile of cuticle at mid-body; R, tail of male, ventral view.

A, F, Q, to scale 500 μm; I, J, K, L, to scale 200 μm; P, to scale 125 μm; B, E, G, M, N, O, R, to scale 100 μm; H, to scale 50 μm.

Diplotriaena falconis (Connal, 1912)

(Fig. 13 P-R)

Material

From *Falco berigora* Vigors & Horsfield, from Yorke Peninsula, S. Aust.: 3♀, 1♂ (AHC 6269).

Description

Additional morphological details are given in Figure 13 P-R.

Measurements

2♀: body length 70, 72 mm; width 590, 660 μm; trident length 135, 135 μm; nerve ring 230, 230 μm from head; vulva 430, 660 μm from head; oesophagus in second female 2550 μm long, with muscular part 400 μm; tail 22, 28 μm; eggs 65 x 30 μm.

♂: body length 45 mm, width 550 μm; trident length 135 μm, oesophagus length 2700 μm, with muscular part 450 μm; tail 32 μm long; left spicule broken, 1025 μm long; right 1100 μm long (850 μm if measured in a straight line).

Discussion

The measurements, general morphology, and the characteristic anatomy of the left spicule agree with those of *D. falconis*, redescribed by Anderson (1959), from Falconidae in Africa. In the Australian specimens, there are ten pairs of papillae in the male, the tail of the female bears papillae, and the cuticle of the female is marked with regular and distinct undulations.

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APPENDIX

Australian Species Described in this Paper, Arranged under their Hosts

Corvidae
- *Corvus orru* Bonaparte
  - *Aprocta bakeri* n.sp.
  - *Diplotriaena beveridgei* n.sp.

Cracticidae
- *Strepera graculina* (Shaw)
  - *Aprocta boulengeri* n.sp.

Muscicapidae
- *Petroica multicolor* (Gmelin)
  - *Pseudaprocta copemani* n.sp.
- *Pachycephala pectoralis* (Latham)
  - *Pseudaprocta copemani* n.sp.
- *Oreoica gutturalis* (Vigors and Horsfield)
  - *Diplotriaena spratti* n.sp.

Maluridae
- *Amytornis goyderi* (Gould)
  - *Diplotriaena delta* Johnston and Mawson

Meliphagidae
- *Acanthogenys rufogularis* Gould
  - *Diplotriaena smithi* n.sp.

Falconidae
- *Falco berigora* (Vigors and Horsfield)
  - *Diplotriaena falconis* (Connal)
  - *Serratospiculum guttatum* (Schneider)
- *Falco peregrinus* Tunstall
  - *S. tendo* (Nitzsch)
- *Falco longipennis* Swainson
  - *Serratospiculum guttatum* (Schneider)

Strigidae
- *Ninox novaeseelandiae* (Gmelin)
  - *Lissonema* sp.

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25 AUG 1982

OBSERVATIONS ON *CHYZERIA* CANESTRINI AND SOME RELATED GENERA (ACARINA: TROMBIDIOIDEA) WITH REMARKS ON THE CLASSIFICATION OF THE SUPERFAMILY AND DESCRIPTION OF A PYGMEPHORID MITE PHORETIC ON *CHYZERIA*

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ABSTRACT

SOUTHCOTT, R. V. 1982. Observations on *Chyzeria* Canestrini and some related genera (Acarina: Trombidioidea) with remarks on the classification of the superfamily and description of a pygemphorid mite phoretic on *Chyzeria*. *Rec. S. Aust. Mus.* **18** (14): 285-326.

The taxonomy of the Australian larvae of the genus *Chyzeria* Canestrini, 1897, is revised. Two new species, *Chyzeria flindersi* sp. nov., from Tasmania, and *C. derricki* sp. nov., from Queensland, are described. In addition, the larva of *C. hirsti* Womersley, 1934 is redescribed from material reared in South Australia. The species *Grossia onychia* Womersley, 1954 is redescribed, from the type specimen from Victoria, and placed in *Chyzeria* as *C. onychia* (Wom.), comb. nov.

Details of the rearing of larvae of *C. hirsti* from adult specimens are given. The species appears to be viviparous, and the larvae are carried phoretically on the mother's back. Such behaviour allows some allotment of function to the digitations upon the dorsum of the adult, and the specialized hair characteristics of the intervening area. Parasitization of larval *Chyzeria* upon a host is recorded only in two instances, these being the record of the type series of *C. derricki* sp. nov. on an unidentified tettigoniid grasshopper, and the earlier record of *C. onychia* (Womersley) parasitizing an adult identified by Womersley as *Chyzeria australiensis* Hirst.

A description of the adult of *Chyzeria hirsti* Womersley (elevated from a subspecies to a species here) from the holotype is given, and some comparison made with the *Chyzeria australiensis* Hirst, 1928, type series from Western Australia.

The classification of the larvae of *Chyzeria, Grossia, Audyana* and others is examined. *Grossia* is considered a synonym of *Chyzeria*. These genera are removed from the subfamilies Apoloniinae and Lasseniinae, where they have been placed by some authors, to the family Trombellidae Feider 1955 (earlier subfamily Trombellinae Thor, 1935) of the Trombidioidea. Larvae of an Australian species of *Womersleyia* Radford are recorded as parasitic upon the cricket *Teleogryllus commodus* (Walker), in northern New South Wales, and nymphs reared experimentally are placed in *Trombella adelaideae* Womersley, 1939, thus allowing the synonymizing of *Womersleyia* with *Trombella* Berlese, 1887. This defines a further larval form of the Trombellidae.

The relationships of some of the genera, families and subfamilies of the Trombidioidea are briefly examined.

A new species of pygmephorid mite (Tarsonemida) is recorded as phoretic upon the dorsum of an adult *Chyzeria hirsti* Wom., and described as *Bakerdania workandae* sp. nov.

INTRODUCTION

In this paper the author records a number of observations on the morphology and biology of the genus *Chyzeria* Canestrini, 1897, with particular reference to the larvae. This genus belongs to the family Trombidiidae (s. l.) of the superfamily Trombidioidea Banks, 1894,* a group of prostigmatic mites which exhibit extreme heteromorphy between the adults (and mobile nymphs) and the larvae. This heteromorphy is in fact so great that in the superfamily the adults and larvae cannot be correlated with each other without experimental rearing. As both larvae and adults have to be described under separate names until such correlations are established, classificatory systems for the post-larval forms may not, and in fact often do not, correspond to that for the larvae, with inevitable confusion, and, in a number of cases, nomenclatorial difficulties. The present paper attempts to place the classification of the larvae related to *Chyzeria* on a firm basis, with detailed descriptions, and biological data where available. Two new species of larval *Chyzeria* will be described, and additionally, two previously recorded species will be redescribed, one being *C. onychia* (Womersley, 1954), n. comb., previously *Grossia onychia* Wom.

*Although this superfamily name was first proposed as such by Banks in 1894, under Article 36 of the International Code of Zoological Nomenclature, 1961, all categories in the family-group (which includes the superfamily category) are of co-ordinate status. As it is generally accepted that the family name Trombidiidae was first validly proposed by Leach in 1815 as "Trombidides", the superfamily name Trombidioidea is available from the year 1815 (See Oudemans, 1937; Thor and Willmann, 1947; Southcott, 1957d).

The trombidiid mite genus *Chyzeria* was founded by Canestrini in 1897, with the adult *C. ornata* Canestrini, 1897, as the type species, collected at Friedrich Wilhelmshafen (later Madang) in New Guinea. Since that time several further species have been described from Australia (including Tasmania), New Zealand, Africa and South America (Hirst 1924, 1928a, b, 1929; Womersley 1934, 1942; Lawrence 1944; Thor and Willmann 1947; André and Lelièvre-Farjon 1960).

The three genera *Trombella* Berlese, 1887, *Chyzeria* and *Parachyzeria* Hirst, 1926, based on adults, were placed in the subfamily Trombellinae Thor, 1935 by Thor and Willmann (1947) in their monographic review of the taxonomy of the family Trombidiidae; this subfamily was separated from all others of the Trombidiidae on the ground of its lack of a crista metopica. Within the subfamily, adults of *Chyzeria* are distinct in possessing a series of digitations arranged around the rim of the dorsum of the idiosoma. These digitations are covered by two types of normal body setae (scobalae): one stiff and swordlike, the other flexible, longer and ciliated. In between these digitations the central dorsal area of the idiosoma is covered with another type of modified scobalae. In at least two Australian species, *C. australiensis* Hirst and *C. hirsti* Womersley, these last-named setae are modified to long, unciliated, highly convoluted hairs.

The genus *Parachyzeria*, known from Africa and Asia, is similar to *Chyzeria*, with a central area of modified setae dorsally upon the idiosoma (these being long and straight), but lacks the peripheral processes.

No suggestion has been made as to the possible function of the peculiar structural adaptations of these mites, although in the case of *Chyzeria*, the opportunity to do so, to at least some degree, existed over 40 years ago.

In 1938 I made a series of attempts to correlate larval and postlarval forms of trombidiid mites by experimental rearings, using South Australian material. Among genera reared, and made available to Herbert Womersley, then Entomologist, South Australian Museum, was *Chyzeria*. These larvae were described by Womersley in 1939, and allotted to *Chyzeria australiensis* Hirst, 1928, despite the fact that all adult *Chyzeria* from the "Adelaide District" he had examined earlier (Womersley, 1934) were allotted by him to *C. australiense* (sic) var. *hirsti* Wom. 1934.

I had seen these reared larvae in captivity on the adult's back. At times they ventured away to the soil below and then returned to the protection presumably afforded by the dorsum of the idiosoma of the parent. These observations were recounted to Womersley and offered for incorporation in his article, but although he was prepared to describe the larvae with their unusual morphological structure, he chose not to include the observations, possibly doubting their accuracy or relevance, or more likely being little interested in details of mite behaviour.

Womersley recognized that these larval mites, with their bizarre complement of dorsal and ventral setae, as well as unusual palp and (pedi)tarsal claw structure, were very different from any previously described trombidiid mites. They will be placed here as *Chyzeria hirsti* Womersley, 1934.

After returning to South Australia from military duties I made a number of attempts to rear larvae of *Chyzeria*, and on three further occasions I obtained larvae from adults. These experiments are recorded below, and confirm the larva-adult correlation originally seen in 1938.

The larval *Chyzeria hirsti* has each of its three pairs of legs 7-segmented (including the coxa); i.e. its leg segmental formula is 7, 7, 7. Its leg coxae have two setae upon coxa I, and one each upon coxae II and III, i.e. its leg coxal formula is 2, 1, 1.

In late 1945 I captured a larval trombidiid mite at Lake St. Clair, Tasmania, walking up the trunk of a eucalypt. This mite was very similar to the larval *Chyzeria hirsti*, and was clearly referable to the same genus. It had a trifid palpal tibial claw, 7-segmented legs, dorsal idiosomal setae placed upon expanded plates, leg coxal formula 2, 1, 1, and a number of other resemblances. The most obvious difference lay in the lack of modification of the scutalae, particularly the AL scutalae. This specimen is described in the present paper as the holotype of *Chyzeria flindersi* sp.nov.

In 1954 Womersley (p. 111) described as a new genus and species *Grossia onychia* Wom. 1954, a larval trombidiid mite which had been collected attached to an adult identified as *Chyzeria australiensis* Hirst in the Otway Ranges, Victoria, in 1951.

In 1947 Wharton had revised the classification of the subfamilies of the chigger mites, family Trombiculidae Ewing 1929*, separating them on the characters shown in Table 1.

*Formally proposed as such by Ewing (1944).

TABLE 1. CLASSIFICATION OF SUBFAMILIES OF TROMBICULIDAE, AS PROPOSED BY WHARTON (1947).

	Leg segmental formula	Coxal setal formula	Tracheae	Median scutal setae	Anterior scutal projection	Sternal setae
Subfamily Leeuwenhoekiinae Womersley (1944) (= Leeuwenhoekiidae, Womersley, 1944*	6, 6, 6	2, —, —	Present	Frequently 2	(?Frequently) present	No more than 2
Subfamily Walchiinae Ewing, 1946	7, 6, 6	1, —, —	Absent	(1)	(Absent)	At least 4
Subfamily Apoloniinae Wharton, 1947	7, 7, 7	1, —, —	Present	(1-2)	Present	(4)
Subfamily Trombiculinae Ewing, 1929	7, 7, 7	—, —, —	Absent	1	Absent	At least 4

*Formally proposed as such by Womersley (1945).

Womersley's *Grossia onychia* has a leg segmental formula 7, 7, 7, and a leg coxal formula of 2, 1, 1. He placed it in the subfamily Apoloniinae, whose definition had been enlarged by Wharton and Fuller in 1952, to accommodate the genus *Sauracarella* Lawrence 1949, which has a leg segmental formula of 7, 7, 7, but with a coxal setal formula of 1, 1(2), 1 and lacked tracheae, and also has expanded sensillary setae; the earlier criterion of "posterior lateral scutal setae not on the scutum" was omitted.

In the same paper (1954a) Womersley revised the taxonomy of a number of larval mites he placed in the family Leeuwenhoekiidae, subfamily Apoloniinae. In addition to the larval genera that he declared had been placed in the Apoloniinae by previous authors—*Apolonia* Torres and Braga, 1938 and *Womersleyia* 'Wharton' (actually the genus placed there by Wharton in 1947 was *Womersia* Wharton, 1947) and *Sauracarella* Lawrence, 1949—he included formally six further genera, these being *Cockingsia* Womersley, 1954, *Audyana* Womersley, 1954, *Mackerrasiella* Womersley, 1954, *Neotrombidium* Leonardi 1901 (with *Monunguis* Wharton 1938 as a synonym), *Grossia* nov., *Nothotrombicula* Dumbleton, 1947 and *Womersleyia* Radford, 1946. In his paper Womersley stated that 'This is a heterogeneous assemblage of genera', which subsequent studies have amply confirmed. The genus *Mackerrasiella* has been shown by Vercammen-Grandjean (1972) to be one of the Hydrachnellae, genus *Hydryphantes* Koch, 1841 and falls in synonymy. The genus *Audyana* was placed alternatively, in the same paper by Womersley, in the subfamily Trombellinae Thor 1935, since larvae had been reared to nymphs resembling *Trombella*, in Malaya. Additionally it may be commented that of the genera listed by Womersley, *Grossia*, *Nothotrombicula* and *Womersleyia* have leg segmental formula 7, 7, 7, while *Cockingsia*, *Audyana* and *Mackerrasiella* have leg segmental formula 7, 6, 6. Womersley (*loc. cit.*) included also in his key to the genera the genera *Neotrombidium* Leonardi, 1901 and *Monunguis* Wharton, 1938, stating in error that they had leg segmental formula 7, 7, 7; actually in *Neotrombidium* it is 7, 6, 6, and in *Monunguis* 6, 6, 6, which Womersley eventually recognized (published posthumously (Womersley, 1963)).

The resemblance between the larvae of *Chyzeria* as described by Womersley in 1939, *Grossia onychia* Wom. 1954, and *Nothotrombicula deinacridae* Dumbleton, 1947, from New Zealand is striking, but in this (1954a) paper Womersley made no reference to it. Evidently, by 1953-1954, he had forgotten his 1939 description. Another possible factor may have been the inaccuracies in his account of the *Chyzeria* larva, of which the claws of the tarsi of the legs were stated to have 'claws three, the lateral ones clavate . . .' while in *Grossia* each leg tarsus was stated to possess 'paired spathulate setae on each tarsus at the base of the single claw', these lateral claws also being referred to as 'a pair of shorter [than the central tarsal claw] apically spathulate tenent setae'. Both *Grossia onychia* and *Nothotrombicula deinacridae* have been redescribed by Vercammen-Grandjean (1972), as possessing spathulate neolateral pedotarsal claws (see the anatomical terminology in Southcott 1961a).

In 1968 Vercammen-Grandjean and Kolebinova revised the subfamily Apoloniinae, restricting it to seven species, allotted among six genera; these were arranged in two tribes, the Apoloniini and the Sauracarellini. They rejected all of the genera included in the Apoloniinae by Womersley (1954a), with the exception of the type genus *Apolonia*.

As stated above, Vercammen-Grandjean (1972) reexamined the status of the mites that Womersley had placed in his greatly expanded Apoloniinae. He placed both *Grossia* and *Nothotrombicula* in the subfamily Lasseninae (sic, for Lasseniinae) Newell, 1957, of the family Johnstonianidae Thor, 1935* (formerly Johnstonianinae Thor, 1935). Vercammen-Grandjean made no reference in his paper to the larval *Chyzeria* that Womersley had described in 1939.

* Formally elevated as such by Newell (1957).

The subfamily Johnstonianinae had been founded by Thor in 1935 for those (adult) Trombidiidae, in which a distinct crista metopica is present, with two pairs of dorsal sensilla, together with some minor and less specific features. This was a distinct group, elevated to family status as Johnstonianidae by Newell (1957), in a study of a series of trombidioid mites from Hawaii and North America, on the ground that these mites differed so profoundly from other terrestrial Parasitengona that they could not logically be retained in the old family Trombidiidae. The differences were, in fact, greater than used by Ewing to separate off the family Trombiculidae from the remaining Trombidiidae. In that study Newell included seven genera in the family, which he divided into the subfamilies Johnstonianinae Thor and Lasseniinae Newell, 1957. The latter subfamily was erected for the general *Lassenia* Newell, 1957, *Polydiscia* Methlagl, 1928 and *Crossothrombium* Womersley, 1939. *Lassenia* was founded on *L. lasseni* Newell, 1957 as type genus, an adult mite in which the principal character was the great reduction of the anterior sensilla when compared with the posterior sensilla. As well as two species of adults, Newell *(loc. cit.)* described two species of larvae, which he placed in the genus on morphological characters and field association, but without the confirmation of experimental rearing. In these larvae the dorsal scutum carries two pairs of normal setae (scutalae) as well as the two pairs of sensilla. Newell made no reference to any genera of Trombiculidae (Trombiculinae) nor the Leeuwenhoekiidae (Leeuwenhoekiinae), nor to the genus *Chyzeria* or other Trombellinae.

In 1973 Vercammen-Grandjean submitted a classification of the Trombidioidea, divided into eight families and a number of subfamilies and tribes. Among the families considered were listed Trombellidae, Johnstonianidae, Neotrombidiidae nov., and Leeuwenhoekiidae. In that revision he placed *Chyzeria* in the Trombellidae and *Grossia* in the Johnstonianidae. *Womersleyia* appears to have been omitted.

As it is not possible in the present paper to deal with the overall classification of the Trombidioidea, it is proposed to submit a detailed examination of the status of the genera *Chyzeria* and *Grossia*, and to make some incidental reference to some other taxa, in an effort to clarify the relationships of several genera of the Trombidioidea.

Table 2 lists a number of genera of larval Trombidioidea which have been referred to either the Trombellinae, Leeuwenhoekiinae (Leeuwenhoekiidae), Lasseniinae or Apoloniinae by various authors, as well as several genera of other families of the superfamily Trombidioidea which are included for purposes of comparison.

TABLE 2. POSSIBLY SIGNIFICANT GENERIC CHARACTERS FOR THE LARVAE* IN A NUMBER OF THE SUPERFAMILY TROMBIDIOIDEA.

	Cx1	Cx2	Cx3	LI	LII	LIII	AM	PL	Nas	Claws	SS	
Chyzeria	2	1	1	7	7	7	0	2	0	3	2	
Grossia	2	1	1	7	7	7	0	2	0	3	2	
Nothotrombicula	2	1	1	7	7	7	0	2	1	3	2	
Chatia	2	1	5-7	6	6	6	2	2	0	2	2	
Monunguis	1	1	1	6	6	6	2	2	1	1	2	
Neotrombidium	2	1	1	7	6	6	2	2	1	1	2	
Cockingsia	2	1	1	7	6	6	2	2	1	1	2	
Leeuwenhoekia	2	1	1	6	6	6	2	2	1	3	2	T
Audyana	2	1	1	7	6	6	2	2	0	1	2	
Apolonia	1	1	1	7	7	7	2	0	1	3	2	T
Womersia	1	1	1	7	7	7	1	0	1	3	2	T
Womersleyia	2	1	1	6	6	6	2	2	1	1,1,2	2	
Mackerrasiella (=Hydryphantes)	2	1	1	7	7	7	0	?2	0	1	?4	
Eutrombicula	1	1	1	7	7	7	1	2	0	3	2	
Babiangia	1	1	1	7	7	7	1	2	0	3	2	
Odontacarus	2	1	1	6	6	6	2	2	1	3	2	T
Vatacarus	1	1	1	7	7	7	1	2	0	3	2	
Pteridopus	2	1	1	7	7	7	0	2	(1)	3	4	
Polydiscia	2	1	2	7	7	7	0	2	(1)	3	4	
Durenia	2	1	1	6	6	6	2	2	1	1,1,2	2	T
Taraxithrombium	2	1	1	7	6	6	2	2	1	1	2	
Podothrombium	2	1	1	6	6	6	2	2	1	3	2	
Ralphaudyna	2	1	1	7	7	7	0(?2)	2	1	3	4(2?)	
Walchia	1	1	1–3 (+)	7	6	6	0	2	0	3	2	
Lassenia lasseni	2	2	3–4	6	6	6	0	2	0	3	4	
Lassenia scutellata	2	1	2	6	6	6	0	2	0	3	4	
Sauracarella	1	1(2)	1	7	7	7	2	2	1	3	2	

T Tracheae present

* The listing of a genus in this Table does not imply that I necessarily accept that these genera are all distinct from each other; nor that they are particularly related to each other.

The abbreviations used are Cx1, 2 and 3, the number of coxalae or setae upon the ventral surface of the coxae (i.e. omitting supracoxalae), L I, II and III, the numbers of segments in the legs, including the coxae (the traditional term coxae being used here, in place of terms introduced by later authors); AM, the number of anteromedian setae (scutalae) to the dorsal scutum; PL the number of posterolateral scutalae to the dorsal scutum; Nas, the presence (1) or absence (0) of a "nasus" or anterior projection to the dorsal scutum; SS, the total number of scutal sensilla. The information is derived from the most recent or accurate authorities on these data, as quoted in the list of references, or from the detailed descriptions given in the present paper.

It is clear that the classification of the larval Trombidioidea is not yet on a firm basis, since we have, for example, various classifications for a fairly homogeneous group of larvae related to *Chyzeria*, these having been placed in the subfamilies Trombellinae, Apoloniinae and Lasseniinae by different authors.

It is proposed in this paper to re-examine and redescribe the larvae of *Chyzeria* (including *Grossia*) from the further material now available, and to attempt to define the characters of the Trombellinae (Trombellidae) for larvae. The relationships of the genera *Neotrombidium, Monunguis* and *Cockingsia* have already been examined by the writer in other papers (Southcott 1954a. 1957c) as well as by others, and any further consideration will be deferred to later works. The larva of the genus *Audyana* Womersley, 1954, with its leg segmentation formula 7, 6, 6 and single-clawed pedotarsi, appears at first sight to be not particularly related to the Trombellinae considered here. Nevertheless, it has been correlated by rearing.

One further genus was placed by Womersley (1954a) in his expanded Apoloniinae, namely *Womersleyia* Radford, 1946. In an earlier draft of the present paper I had written that although this appeared to be a well-defined genus, there was no strong evidence to connect it with *Chyzeria, Grossia* and *Nothotrombicula* and had decided to exclude it from further consideration in the present paper. Recently, however, I have been sent a batch of larval orange-coloured mites taken as ectoparasites on adults of *Teleogryllus commodus* (Walker), the field cricket, collected 10 km N of Armidale, New South Wales, on 12 and 19 March 1980, by Mr Steve Davidson. These proved to be typical *Womersleyia*, but the leg segmentation formula is 6, 6, 6, and not 7, 7, 7, as recorded by Womersley (1954a, p. 114). (Vercammen-Grandjean (1972) had corrected this for *W. minuta* Radford.) It has been possible to rear a number of these larvae to nymphs, which are typical *Trombella*, keying down (as far as is possible for nymphs) to *Trombella adelaideae* Womersley, 1939, in the key of Womersley (1954b, p. 128).* The further description of these Australian larval *Trombella* and their nymphs will be dealt with in later papers.

A further genus referred to the Trombellidae was *Ralphaudyna* Vercammen-Grandjean *et al.*, 1974, this action being based on its morphology. It is interesting to note, however, that there are significant resemblances to those larvae allotted by Newell (1957) to *Lassenia* in the dorsal scutum and other features.

At the present time it is probably fair to consider that larval trombidioid mites which can reasonably be allotted to the Trombellidae are species ascribed to the genera *Chyzeria, Nothotrombicula, Womersleyia (=Trombella), Audyana* and *Ralphaudyna.*

*As a consequence, Radford's species is here re-named *Trombella minuta* (Radford, 1946), comb. nov.

SUBFAMILY AND FAMILY CONSIDERATIONS

Within the family Trombidiidae Leach, 1815, as defined by Thor (1935) and Thor and Willmann (1947), a number of groups have been separated off into families, e.g.

Trombiculidae Ewing, 1929*, Leeuwenhoekiidae Womersley, 1944*, Vatacaridae Southcott, 1957, Johnstonianidae*, Calotrombidiidae (sic) Feider, 1959, and a number of others. Among these is the family Trombellidae (formally proposed as such by Feider (1955)), based upon the genus *Trombella* Berlese, 1887, and erected originally as the subfamily Trombellinae Thor, 1935.

Family Trombellidae Thor, 1935

Syn. Trombellinae Thor, 1935; Thor and Willmann, 1947; Trombellidae Feider, 1955

Definition

Trombidioid** mites lacking a crista metopica in the adult and active nymphal stages. Propodosoma carries a pair of dorsal sensilla. Definition of larva deferred.

Key to Larval Genera of the Family Trombellidae

1 Leg segmental formula 7, 7, 7 2
Leg segmental formula 7, 6, 6 or 6, 6, 6 4
2 (1) Dorsal scutum lacking anteromedian projection ("nasus") ..... *Chyzeria* Canestrini 1897

*See earlier comments in this paper on the formal dates on which these names were proposed.

**For a definition of Trombidioidea, see Southcott (1957d, p.173).

Dorsal scutum with anteromedian projection ("nasus") . . 3
3 (2) Dorsal scutum with 8 setae
Ralphaudyna Vercammen-Grandjean *et al.* 1974
Dorsal scutum with 6 setae *Nothotrombicula* Dumbleton 1947
4 (1) Leg segmental formula 7, 6, 6 *Audyana* Womersley 1954
Leg segmental formula 6, 6, 6 . . . . *Trombella* Berlese 1887 (=*Womersleyia* Radford 1946)

Genus *Chyzeria* Canestrini

Chyzeria Canestrini 1897, p. 463; 1899, p. 390. Hirst 1924, p. 1077; 1928a p. 563; 1928b p. 1021; 1929 p. 165. Vitzthum 1931 p. 148; 1942 p. 286. Womersley 1934 p. 182; 1937, pp. 75, 76; 1939, p. 155; 1942, p. 169. Lawrence 1944 p. 438. Thor and Willmann 1947 p. 203. Baker and Wharton 1952 p. 250. Vercammen-Grandjean 1955 p. 260; 1973b p. 110. André and Lelièvre-Farjon 1960 p. 461. Southcott 1961a p. 563. André 1962 p. 124; 1963 p. 561. Vercammen-Grandjean and Kolebinbova 1968 p. 250. Robaux 1969 p. 69. Krantz 1978, p. 351.

Grossia (as larva) Womersley 1954a p. 111. Audy 1954 p. 166; 1957 p. 442. Vercammen-Grandjean 1967 p. 2; 1971b p. 315; 1972 p. 231; 1973a p. 58; 1973b p. 110. Robaux 1977a p. 666.

Type species: *Chyzeria ornata* Canestrini, 1897, (original designation)

Definition of Adult

Trombidiidae without well-defined crista metopica, but a shield may be present in the central area of dorsum of propodosoma. A pair of dorsal idiosomal sensilla may arise upon a protuberance usually anterior to the level of the eyes. Eyes 2 + 2, sessile. Dorsum of idiosoma with a lateral column of finger-like processes, covered with setae which may be of two distinct types, the one stiff and pointed, the other flexible. Additionally there may be a dorsal anteromedian projection arising about level with the most anterior of the dorsolateral projections, and a posteromedial projection. Area between the dorsal projections of the idiosoma with numerous fine, long, convoluted setae.

Definition of Larva

Trombidiid larvae with a single prodorsal scutum, transversely placed, with AL and PL scutalae placed towards AL and PL angles respectively of scutum. No anteromedian scutalae. A pair of scutal sensilla present, widely separated, placed at about the mid-level of scutum. Sensillary hairs filiform, ciliated. Eyes 2 + 2, conjoined, sessile, placed laterally or posterolaterally to scutum. Intercoxal formula 0, 0, 2. Pedocoxal formula 2, 1, 1. Legs with divided femora, i.e. leg segmental formula 7, 7, 7 (including coxae). Pedocoxalae may be short, stout, pointed, blunted, peg-like, smooth or irregular. Pedotarsal claws all rather slender: anterior terminating in expanded suction-membrane; middle (neomedian) claw normal, more or less falciform; posterior claw similar to anterior. Palpal tibial claw strong, divided into three strong divergent tines. Idiosomal setae may arise from small plates, these being expansions of the normal alveolar annulus of the seta. Ventral setae may have the basal part of the shaft (scobillum) thickened.

Key to Known Larvae of *Chyzeria*

1. AL scutalae short, blunt, robust, somewhat expanded, with short, strong serrations, about 17-20 μm long. Pedicoxalae short, blunted, multituberculate, with tubercles present along most of the setal shaft (scobillum). Posterior dorsal idiosomalae to about 46 μm long
. *Chyzeria hirsti* Womersley, 1934 (South Australia)
AL scutalae normal, tapering, moderately pointed, more or less ciliated. Pedicoxalae either tapering, pointed and ciliated, or blunted and tuberculate, but in the latter case with the tubercles absent in the proximal half of the scobillum. Posterior dorsal idiosomal setae in range of 75-140 μm 2
2. (1) Pedicoxalae pointed or very slightly blunted. AL scutalae about 112 μm long; AL/(A-P)>2.1
Chyzeria onychia (Womersley, 1954) (Victoria)
Pedicoxalae very blunt-ended. AL scutalae in range of 55-107 μm long; AL/(A-P)<2.1 3
3. (2) Pedicoxalae weakly tuberculate through the distal half of the setal shaft (scobillum). AL scutalae about 55 μm long; AL/(A-P) about 1.06. Palpal tibial claw tines only slightly divergent . . . . . *Chyzeria flindersi* sp. nov. (Tasmania)
Pedicoxalae weakly tuberculate in about the distal one quarter of the shaft of the seta (scobillum). AL scutalae in range of 88-107 μm long; AL/(A-P) 1.9-2.0. Palpal tibial claw tines widely divergent
. *Chyzeria derricki* sp. nov. (Queensland)

Chyzeria hirsti Womersley

(Figs. 1A, B; 2 A-E; 3; 4 A-D)

Chyzeria australiense (sic) var. *hirsti* Womersley, 1934 p. 182; Womersely 1937, p. 76 (as adult)

Chyzeria australiense (sic) Womersley, 1939, p. 155 (as larva)

Nec C. australiense (sic) Hirst 1928 (1928a) p. 563 (adult)

Description of Larva (based largely upon specimen ACB 13/14 L1) (Figs. 1A, B; 2A-G) Colour in life red. Length of idiosoma (mounted on slide) 285μm, width 190μm; total length of animal from tip of chelicerae to posterior pole of idiosoma 360μm.

Dorsal scutum about twice as wide as long, trapezoidal with somewhat rounded angles, the scutum widest posteriad. Anterior margin somewhat sinuous, posterior margin somewhat convex (a little angulated in the middle), lateral margins slightly concave. Scutal sensilla very widely separated, and behind level of middle of scutum. AL scutalae placed towards AL angles of scutum, PL scutalae towards PL angles of scutum.

TABLE 3. STANDARD AND OTHER DATA FOR SOME LARVAE OF *Chyzeria hirsti*

Designated variate	Specimen						
	ACB 13/14 L1	ACB 13/14 L2	ACB322 L1	ACB322 L2	ACB468 L1	ACB468 L2	ACB526 L1
AW	86	83	75	79	78	77	82
PW	110	116	104	96	110	107	109
SB	61	66	57	55	57	59	60
ASBa	39	37	35	33	28	28	38
ASBp	29	28	26	22	ca18	29	27
L	68	65	61	55	ca46	57	64
W	126	134	ca123	109	149	138	140
A-P	32	31	31	29	32	31	29
AL	18	19	20	17	18	19	17
PL	29	25	29	29	29	33	29
Sens	59	63	53	50	61	57	—
DS	29-57	35-57	24-49	40-52	33-42	33-66	42-50
mid-DS	39-44	35-42	39-40	40	42	39-66	42
PDS	45	44	24-37	44	37-46	33-39	39-42

Anterior scutalae short, robust, spindle-shaped, ciliated, the cilia blunted, outstanding a little and thus the AL scutala resembles a distorted partly opened pine-cone with about 9 bracts; posterior scutalae rather longer, pointed, elongate-spindle-shaped, with projecting barbed pointed cilia. Scutal sensillary hairs slender, with distal sparse cilia.

Eyes 2 + 2, sessile, near PL angles of scutum; corneae oval to ovoid, posterior the larger. Anterior cornea has maximum diameter 15μm, posterior has maximum diameter 19μm.

Dorsal idiosomalae long, very slightly tapering, pointed, slightly ciliated with barbed cilia. Setae arise from small plates, oval or somewhat straight-edged where they impinge upon each other; plates are expansions of normal annuli of alveolar sockets; setae usually arise eccentrically upon the plates. Setae arranged 6, 6, 6, 6, 2; total 26.

Venter lacking setae on idiosoma between coxae I and II. Between coxae III a pair of radish-shaped setae, having an expanded basal part to the shaft (scobillum), the remainder long, tapering, pointed; setae 17μm long. Behind the level of coxae III are about 30 setae (apart from the four anals), similar to the last, arranged in somewhat irregular transverse rows across the ventral opisthosoma. These setae change in character as one proceeds posteriad. The more anterior setae are short and "radish-like" or "parsnip-like", with a thickened basal part of the scobillum and a maximum thickness at about the middle of the seta, and are similar to the pair between coxae III. All ventral idiosomal setae arise from small basal plates (expanded annuli). Posteriad the setae gradually become more elongate, more ciliated and stronger, but lose the bulbous expansion. Setae of anterior row are 16-21μm long, and the posterior setae to 37μm long. Anus with two oval valves, 45μm long by 37μm across with the valve lips in apposition. Each anal valve with two long setae, anterior pointed, ciliated 22μm long, posterior blunted, ciliated 28μm long. Idiosomal setae lateral to anus tapering, pointed, elongate, 35μm long.

Coxalae 2, 1, 1. All coxalae short, stout, unciliated, with indefinite coarse tuberculations in lateral aspect, and terminally somewhat bifid, resembling an irregular plum in shape; setae 9-11μm long by 5-7μm across. The tuberculations number about 7, and are placed more or less distally upon the setal shaft or scobillum.

Legs normal, with the distal ends of femora, genua and tibiae tending to expand. Leg I 375μm long, II 380μm, III 420μm (all lengths include coxae and claws). Leg scobalae normal, curved, ciliated, terminally pointed or blunted.

Tarsus 96μm long by 29μm high, tibia I 55μm long, genu I 46μm (TiI/GeI = 1.20); tarsus III 101μm long by 24μm high, tibia III 55μm, genu III 54μm (TiIII/GeIII = 1.01). (Tarsal lengths given exclude claws and pedicle.). Genu I with specialized seta VsGeI.77pd; tibia I with SoTiI.14ad, SoTiI.86ad, VsTiI.86pd. Genu II with specialized seta VsGeII.79pd. Tibia III with specialized seta SoTiIII.22pd. Tarsal setae as figured. Tarsal pedicle normal. Pedotarsal claws: anterior and posterior slender, spathulate, middle (neomedian) falciform, slender, unciliated, with sharp terminal downturned tip.

Gnathosoma rather small, compact, flattened pos-

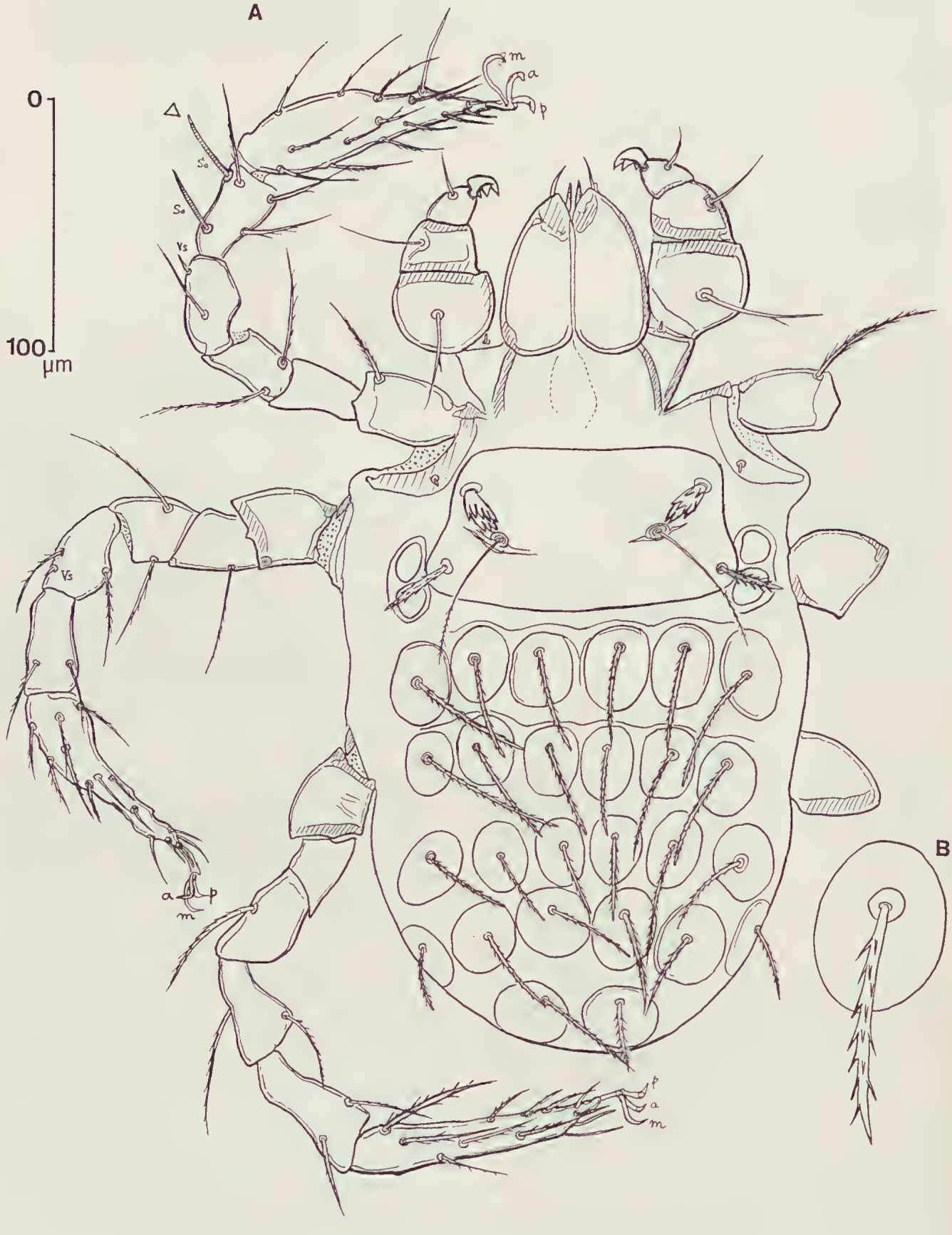

FIG. 1. *Chyzeria hirsti* Womersley, larva, specimen ACB13/14 L1. A, Dorsal view, legs on right hand side of figure omitted beyond trochanters; to scale on left. B, Detail of a dorsal idiosomal seta and its basal plate; not to scale.

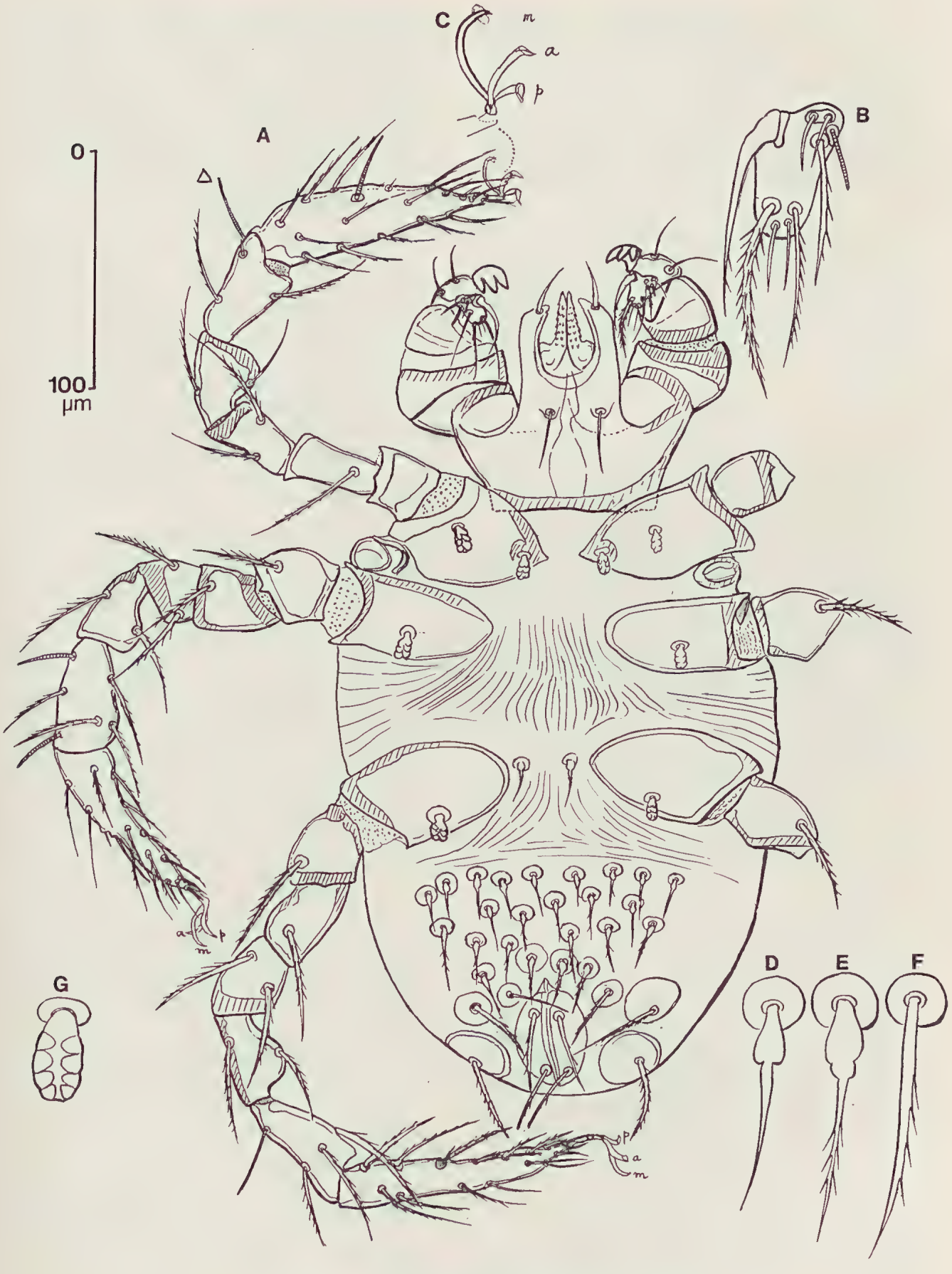

FIG. 2. *Chyzeria hirsti* Womersley, larva, specimen ACB13/14 L1. A, Ventral view, legs on right hand side of figure omitted beyond trochanters; to scale on left. B, Palpal tarsus, enlarged. C, Claws of tarsus I, enlarged. D, E, F, Posterior ventral idiosomal setae, enlarged. G, Pedocoxal seta, enlarged. (B-G not to scale.)

teriorly. Chelicerae bases 74μm long to tip of cheliceral blades, by 55μm across conjoined. Cheliceral blades small, curved, sharp-tipped, with small teeth along cutting edge and other surfaces. Galeala spiniform, robust, curved, simple, slightly blade-like, terminally pointed, 17μm long. A delicate circular lip surrounds the tip of the chelicerae. Anterior hypostomala not identified. Posterior hypostomala very slender, tapering, unciliated, 30μm long.

Palpi as figured. Palpal setal formula 0, 1, 1, 3, 9. Palpal femorala tapering, with one barbed ciliation, 37μm long. Palpal genuala tapering, pointed, unciliated, 26μm long. Palpal tarsal setae as figured. Palpal tibial claw (odontus) with three strong slightly divergent tines. Palpal supracoxala a slender blunted peg, 4μm long.

SOURCE OF *Chyzeria hirsti* LARVAE

Larvae of *Chyzeria hirsti* have been obtained on three occasions since 1938 by experimental rearing from the adults confined in tubes of soil.

(1) Serial ACB13, 14. Two adults were captured by the author on a hillside above the property of Birksgate near Glen Osmond, South Australia, on 23 May 1938. These mites were placed in a glass tube with a small amount of soil from their capture site. Local natural unsterilized soil* was used, as with all my similar attempts with many different trombidiids, on the hypothesis that the mites would find food in the form of fungi or small arthropods in the soil. Subsequent notes (abbreviated) were as follows.

13.vi.1938 Both (mites) active. One active and plump, the other smaller and less plump.

2.vii.1938 Both active and well.

10.vii.1938 As 2.vii.1938.

24.vii.1938 Alive and active. Some fresh [unsterilized] soil added.

14.viii.1938 Alive and active.

10.ix.1938 Both active on stimulation. One thin; one plump. One oribatid (mite) and one parasitid (mite were) seen in the tube. There were a number of larval trombid (iid)s seen in the tube. Six were mounted (on a slide). One (further) one was lost. The others (were) kept in the tube. The adults had larvae on their backs, but most of the larvae were free.

12.ix.1938 One larva put into formalin.

13.ix.1938 Adults alive and active. Not less than three larval trombid(iid)s were free, running around inside the tube. One *Chyzeria* adult had two larvae on the dorsum; the other adult had four larvae on the dorsum. The larvae were not attached by their mouthparts. They ran over the bodies of their parents, without leaving them. [I obviously assumed at the time, presumably from the larval behaviour, that both of the adults were parents of the mites, although in retrospect that conclusion may not have been justified.]

(On examination of the slide-mounted adults one finds that one specimen (ACB13/14A) is clearly a female, the body being clarified in the mountant to show it contains a slightly irregular ovoid egg measuring 295μm by 260μm. No evidence of internal chitinization in the egg is visible; a more definite statement cannot be made on account of the thickness of the setation. In the case of the other adult (ACB13/14B) the sex is indeterminate, as the mite's idiosomal structure is obscured by attached debris, and no eggs can be seen; the genitalia are also obscured.)

So there were at least 17 larvae in all (6 mounted on slide initially, one lost 10.ix.1938, one put in formalin 12.ix.1938, and not less than 9 in the tube).

14.ix.1938 Adults active. Several larvae on dorsum of each adult. None [was] attached by its mouthparts, but all were moving over the surface of the adult, and keeping to the posterior half of the adult for the most part. When on the dorsum of the adults the larvae moved one or two legs at a time, and quickly, with intervals in between so they moved forward jerkily.

Several larvae were seen running round [in] the tube.

One larva was seen to leave the adult by a leg, and to get several mm [away] from the adult, and then return to the dorsum by a leg. (Possibly the larvae reconnoitre [using] the adults as bases.). One larva was seen dead in the tube (lost [on] 17.ix.1938).

15.ix.1938 Adults active; one with 4, other with 3 or more larvae on it. None [was] attached by [its] mouthparts. Two larvae where seen free in the tube.

17.ix.1938 Two [larvae] were taken out (returned later) and put on my arm. They were watched with a strong lens, but neither showed any signs of wanting to pierce the skin. Each was watched for about three minutes. They ran quickly over the skin.

22.ix.1938 Adults active, each with one larva on the posterior part of the dorsum. Larvae not attached by mouthparts, moving as before. Four

* The statement by Womersley (1939, p. 156) that the soil was sterilized was an error on his part.

larvae seen running around tube. One larva seen dead in the tube.

Observations continued over the succeeding weeks. By 24 September 1938 all the larvae were dead, possibly by the tube being made dryer. The tube was then re-wetted. On 8 October 1938 the adults were active. On 22 October they were shrunken and feeble, and on 29 October were dead. On being slide-mounted neither was then seen to contain eggs, nor were eggs seen at any stage in the tube.

(2) Serial ACB322

On 1 August 1948 a very plump adult *Chyzeria* was captured in soil at Workanda Creek, National Park, Belair, South Australia. It was placed in a tube with a little soil. Although examined regularly during the period August to November no eggs or larvae were seen in the tube. On 7 December 1948 two dead larvae were seen in the tube. The adult mite was healthy on 28 December but was dead on 28 January 1949.

No eggs or live larvae were observed in the tube at any stage.

(3) Serial ACB468

An adult *Chyzeria hirsti* was captured at the same site on 3 September, 1950, placed in a tube with some damp soil, and examined as opportunity offered. On 29 October I recorded "Worm in tube. One yellow ?egg in tube. Tube quite damp". On 14 November seven larvae were counted in the tube, several being immobile, trapped in water droplets. The yellow object noted on 29 October remained unaltered in appearance, and I recorded in my notes "I do not doubt [that] it has nothing to do with the *Chyzeria*. To my mind this tube experiment establishes the viviparity of *Chyzeria*.*"

One active larva was then taken out of the tube and manipulated into repeated encounters with the adult, these manoeuvres being aided with a fine brush. Although placed on the back of the adult on three or four occasions, the larva showed no indication to remain there, at once hurrying off. I commented in my notes that the larva looked "in fact like a typical larval *Trombicula*" (the term *Trombicula* indicating here a larval trombiculid mite of the genus *Eutrombicula* and various other genera). On being replaced in the tube, further encounters occurred between the adult and the larva, but the larva made no attempts to climb on its presumed parent's back. The trapped larvae were in a row as though they had been recently laid in a regular fashion, the distance between successive larvae being about 5 or 6 times the length of an individual larva.

On 15 November a few larvae were still alive and healthy, but again no attempt for one to climb on the back of the adult was observed. By 4 December all larvae were dead. The adult appeared active and healthy. However, by 1 January the adult also was dead.

Thus in this experiment no phoretic relationships were observed.

(4) Serial ACB526

On 29 July, 1951 another adult *Chyzeria* from the same site was captured and confined in a tube with some soil. Observations were made at intervals. On 9 September no eggs or larvae were seen in the tube. At the next observation, on 24 October, the adult was recorded as being well, the tube damp. "One larva is present in the tube. It gives the impression of walking on tiptoes more than the larva of *Ettmülleria** etc.—in this it resembles *Trombicula* etc. I watched it encounter its parent several times. At one of these encounters it ran up its parent's leg, over its back and down another leg, then circled widely and returned to the moving parent and walked underneath it. It appears to be attracted by movement.....Only this one larva (was) seen; no egg seen."

On 20 November the tube was rather dry; the adult alive and well. Two dead larvae were seen in the tube.

On 25 November the tube was dry; the adult alive and well.

The adult remained alive until 29 December, but was dead on 27 January, 1952. Only one larva was enventually recovered from the tube.

The time relationships between the adults and the larvae in this experiment are summarized in Table 4.

*(When taken in conjunction with the previous observations).

*The larvae of *Echinothrombium willungae* (Hirst, 1931); see also a note in Southcott (1957a: p. 142).

TABLE 4. SUMMARY OF DATA ON TIME-RELATIONSHIPS OF ADULTS AND LARVAE IN SUCCESSFUL REARING EXPERIMENTS WITH *Chyzeria hirsti* WOM.

Experiment	ACB 13,14	ACB322	ACB468	ACB522
Adult(s) captured	23.v.1938	1.viii.1948	3.ix.1950	29.vii.1951
Larva(e) seen alive	10-22.ix.1938	—	14-15.xi.1950	24.x.1951
Larva first seen dead	14.ix.1938	7.xii.1938	15.xi.1950	20.xi.1951
All larvae dead	23-24.ix.1938	(7.xii.1948)	16.xi.1950-4.xii.1950	20.xi.1951
Adult(s) died	23-29.x.1938	29.xii.1948-28.i.1949	5.xii.1950-1.i.1951	30.xii.1951-27.i.1952

In summary, larvae have appeared on four occasions in tubes containing live adults of *Chyzeria hirsti* confined therein, with unsterile soil as a rearing chamber. Eggs have not been observed. Larvae have appeared alive between September and November and possibly are restricted mainly to the period September-October. No larva has been captured in the field, and at present these larvae are the only ones known of *Chyzeria hirsti*. No evidence of any potential host for these presumably parasitic larvae has been discovered. The adults are used by the larvae in a phoretic relationship, and there has been no evidence of parasitisation of the parent. Man does not appear to be a suitable host for the larva, from a single experiment. (This was expected; it is anticipated that eventually the larvae will be found to parasitise some arthropod host. See also the record for *Chyzeria derricki* sp.nov., below of parasitisation by this species of a tettigoniid host, and also the record for *Chyzeria onychia* (Wom.), in which this species was taken parasitic upon an adult *Chyzeria* sp.).

Comment on Larval Behaviour in *Chyzeria hirsti*

Although over the years 1938-1980 continued efforts have been made, as opportunity offered, to obtain *Chyzeria hirsti* (and other Trombidiidae) larvae from experimental preparations, the only successful attempts with *Chyzeria hirsti* have been those recorded above.

In two of the experiments recorded there was evidence of behavioural interaction between the larvae and the adult(s). In one further instance the observations were negative, while in the fourth experiment the larvae were dead when first observed.

There appears to be no doubt, however, that the larvae of *Chyzeria hirsti* have an unusual behaviour among Acarina, in that they have a phoretic relationship with their parents or parent. The evidence given above clearly indicates that the larvae use the adults as a means of transportation, and hence dispersion, this coming within the formal definition of phoresy. No doubt, in addition, the adults provide shelter and some degree of protection, in that being able to retreat to an elevated niche upon a parent represents some protection from predatory arthropods of a size capable of preying upon animals the size of the *Chyzeria* larva but not of the adult. This extends the relationship between the parent and the larva beyond transportation-utilization or phoresy, into one of protection. Similar extended relationships occur in other arachnids, perhaps the best known ones being in the case of scorpions and lycosid spiders, but such relationships occur widely among various groups of arthropods, particularly the Crustacea, and in fact even more widely and extensively in vertebrates. Thus not only is this seen frequently among Mammalia, but is well-known among Amphibia, and in fact the carrying of juveniles in the mouth or a brood-pouch is also known widely among the fishes.

Among the Acarina, however, although phoretic relationships between mites of a number of families and other arthropods are well-known (see Krantz, 1978), as far as I am aware there has been no previous record among the Acarina of phoretic behaviour occurring between an adult mite and the larva of the same species.

The observations above on maternal care of the larvae help to provide also some explanation for the peculiar structure of at least two species of *Chyzeria*. The dorsum of the idiosoma of the adult carries a number of largely peripheral projections. The area between these projections, in *C. australiensise* and *C. hirsti*, bears a dense mat of fine, convoluted, simple hairs.

In a recent paper Rovner *et al.* (1973) have suggested a possible role for the abdominal setation of the lycosid spiders in terms of maternal-juvenile behaviour. Adult female lycosids have peculiar knobbed hairs on the abdomen. Juveniles will not cling to their mother's abdomen once these hairs have been shaved.

Since the *Chyzeria hirsti* there is an unusual behaviour pattern in the larvae and an unusual structural modification of an area of the adult, where the unusual larval behaviour is manifested, it would be reasonable to interpret the adult structure as possibly subserving the larval-adult behavioural modes. Although in larval *Chyzeria* the anterior and posterior (neolateral) pedotarsal claws are provided terminally with a 'suction' membrane, this adaptation cannot necessarily be considered as related to the adult-larva behaviour, but could possibly serve some other function, such as ensuring adhesion to a thick-skinned host.

It is also reasonable to speculate that the fine convoluted hairs of the adult allow utilization by the larva in its rather jerky mode of progression over the idiosoma. The convoluted hairs appear to be of uniform thickness and unciliated, even when viewed either by phase-contrast or polarized-light microscopy. The shaft (scobillum) outer layer is birefringent, as is usual for any trombidiform normal-type seta (scobala) (see Southcott 1961b, 1963a for details of seta terminology). The undulations or coils (and the terminal hook) on these hairs could serve the same function as e.g. special knobs (as is the case in the lycosid spiders mentioned above) i.e. allowing the larvae better to utilize them in walking or moving across the adult's back. For these setae the name *sericala* is proposed.

These setae are present in both *Chyzeria austral-*

iensis and *C. hirsti*. They are present in some other species of Australian *Chyzeria* with various specific determinations by Womersley, in the South Australian Museum collection. These include specimens from Tasmania, Victoria (but not all) and Queensland. They are not present in three specimens in the collection identified as *C. musgravei* Hirst by Womersley. (I have not seen the type of *C. musgravei*.). These three specimens instead possess in the central dorsal idiosomal space a number of stiff sword-like setae, arising from small plaques (seta-bases), as well as longer, flexible, ciliated setae, arising similarly.

Details of these three specimens are as follows:

(1) ACB715. One specimen. Top of Carrington Drive, Nat[ional] P[ar]k, N.S.W., 31.x.1944, H. W[omersley].

(2) ACB716. Queensland, 1943. No other data.

(3) ACB717 (Two slides) One specimen. In leaf debris, Brookfield Rd., nr Haven Rd. Brookfield, 5.iv.1961. E. H. Derri [c] k [Queensland].

Other Possible Phoretic Usage of *Chyzeria hirsti* Adult

A further usage of an adult *Chyzeria* as a phoretic host has been observed. In that case an adult female of *Chyzeria hirsti,* collected at Workanda Creek, National Park, Belair, South Australia, on 1 August 1948, was observed to be carrying an adult female pygmephorid mite. For further details, see p. 318, and Fig. 18 in this paper.

NOTES ON THE ADULT OF *Chyzeria hirsti* WOMERSLEY

As stated above, Womersley separated this form as a subspecies in 1934. In his discussion on *Chyzeria australiense* (sic), *C. occidentalis* Hirst, 1929 and *C. musgravei* Hirst, 1928 Womersley (p. 182) included the following remarks (after reducing *C. occidentalis* to a 'variety' of *C. australiense* (sic) Hirst, 1928) 'Further, Hirst's *C. musgravei* must also be considered as a variety differing in that the anterior median plate (this is an error for 'process' or 'tuberosity'—R.V.S.) is developed into a compartively long process. One specimen amongst the Hirst material in Professor Harvey Johnston's keeping, and now in the South Australian Museum, is clearly intermediate between the two forms in respect of this character, the process being shorter and triangular. This specimen was labelled in pencil by Hirst as *C. musgravei*. All the specimens collected recently by Mr M. W. Mules and myself in the Adelaide District agree with this intermediate form, for which the name *C. australiense* var. *hirsti* var. nov. is proposed.

'Loc. Type: Willunga, West. Aust.; paratypes: Woodside, S. Aust., July, 1933 (W.M.); Mt Osmond, S. Aust., Sept. 17, 1933 (H.W.); Glen Osmond, S. Aust., Oct. 1, 1933 (H.W.)'.

Womersley also provided (pp. 183-4) a key to the Australian and New Zealand species of *Chyzeria* in which the above differences were restated in separating *C. australiense* (sic) var. *musgravei* from *C. australiense* (sic) var. *hirsti*. The New Zealand species *C. novaezealandiae* Hirst, 1924 was misnamed as *C. novae-hollandiae* Hirst by Womersley, who was then comparatively unfamiliar with the Australian fauna and history.

Although the characters proposed by Womersley (1934) in the separation of this taxon as a subspecies, and presented by him in the text and the key to the species, appear comparatively slight, the present author believes that *hirsti* is worthy of full specific rank and therefore formally raises it to species status now. Again, although this paper does not aim to deal with the classification of the adult *Chyzeria,* some redescription of adult *Chyzeria hirsti* and comparison with *Chyzeria australiensis* Hirst are required.

DESCRIPTION OF THE HOLOTYPE ADULT OF *Chyzeria hirsti* WOMERSLEY, 1934 (FIGS. 3; 4 A-D)

The specimen (identification ACB718) is slide-mounted in clear unstained medium, cleared, decolorized, squashed and disrupted, possibly partly dissected, so that it is difficult to give other than imprecise details of the soft parts. Scattered around the mounted specimen are a number of eggs and skins, without evidence of contained embryos (at least there is no evidence of internal chitinization). The disruption of the animal on the slide is such that it is almost divided into two parts by a line of tearing behind the coxae II, and there is a further oblique tear in the opisthosoma (Fig. 3).

Mite appears to be of normal *Chyzeria* shape and characteristics, with moderately strong legs and gnathosoma, and a somewhat elongate idiosoma with the usual processes. Legs I and IV are about equal in length to the idiosoma, with legs II and III somewhat shorter.

Length of animal on slide from tip of chelicera to tip of posterior idiosomal processes 2900 μm. (The length in life is estimated from the degree of damage to the specimen as about two-thirds of this figure, i.e. ca 1900-2000 μm. Length of idiosoma in the mount 1950 μm, width (at widest part, including edges of dorsal processes) 900 μm.

Eyes 2 + 2, sessile, anterior eye 42 μm across, posterior eye larger, 56 μm across, rather more medial; the two eyes making a conjoined mass 116 μm by 57 μm. In the mid-line, somewhat anterior to the eyes, is a pair of prominent tubercles, each about 46 μm across and high. From each of these sensilla a fine sensillary hair emerges, about 240 μm long. Between the eye masses and the sensillary tubercles is the "sensillary area", which bears about 20 long cilated setae. A few similar setae arise also along the

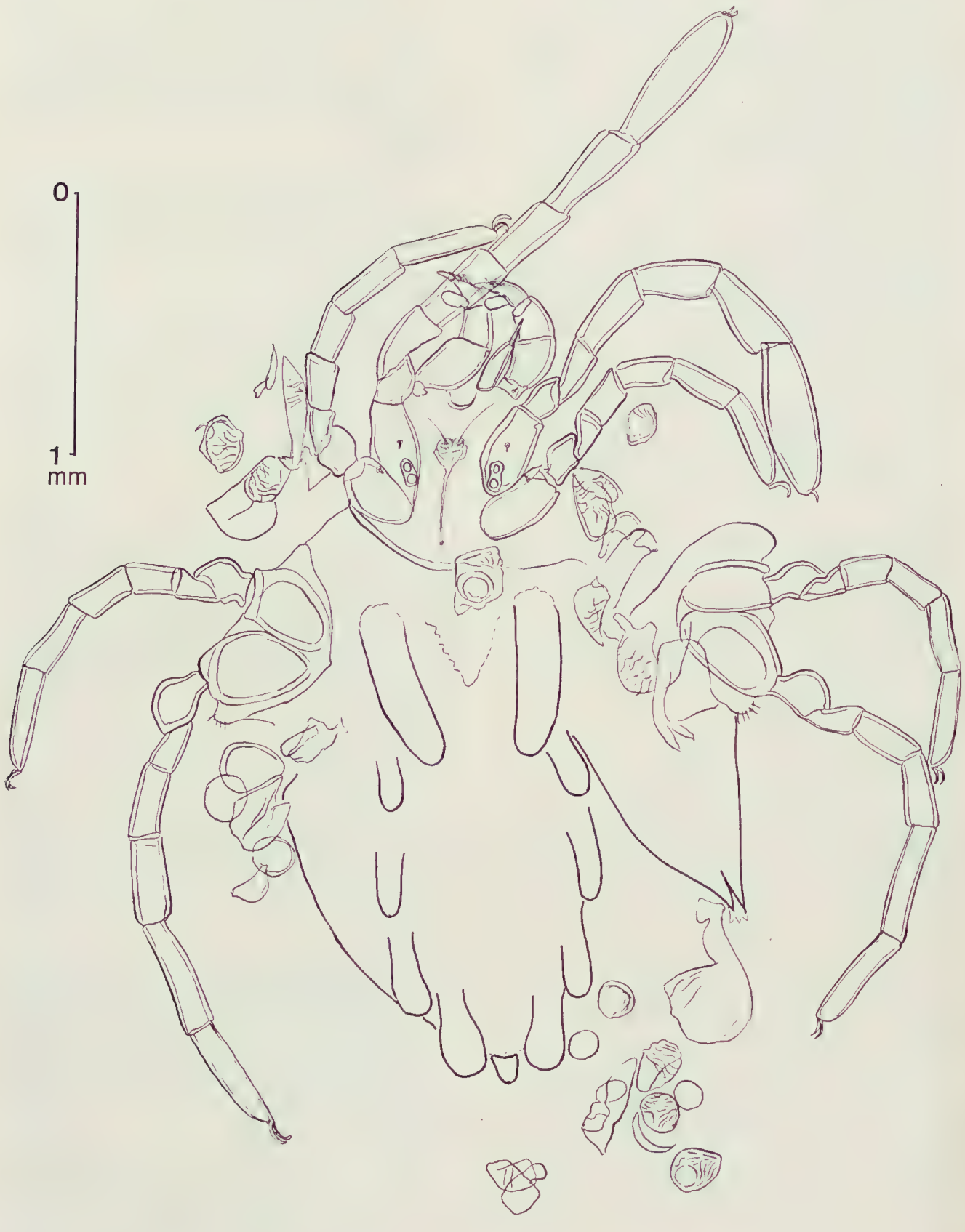

FIG. 3. *Chyzeria hirsti* Womersley, adult. Holotype female, specimen ACB718, shown in transparency (genitalia and anus omitted). The body and leg setae are mostly omitted. The specimen has been ruptured in the mounting process, and ova of various sizes have been released.

medial edges of each eye mass. There is a weak indication of a crista running posteriorly from the sensillary area for about 360 μm; this is thin and has an irregular margin, becoming vaguer and weaker posteriorad.

Dorsum of the idiosoma with the characteristic digitations or projections of the genus. The anteromedian is rather conical, but not well-defined. These projections are all studded with little bosses carrying the setal plates. They carry two kinds of setae (scobalae), the more prominent kind being the stiff spine-like unciliated setae, which project out like spines of a hedgehog, and range from 86-260 μm long. Among the spine-like scobalae are a number of more normal, slender, cilated setae, which project out beyond the spine-like setae. The anterolateral and posterolateral processes are long, more or less round-ended and hence sausage-shaped. In between them are less prominent projections, so that along each side of the dorsum of the idiosoma is a column of five more or less distinct projections. The second and third processes project the least, but are still distinct. The two most posterior projections are bulbous. There appears also to be a posteromedial projection, probably somewhat ventrally placed, but as in the specimen it is detached and displaced away from the idiosoma between the two most posterior projections, its exact placing is not determinable in this specimen.

In the central area of the dorsum of the idiosoma is a large number of long fine convoluted hairs, each rising from an expanded seta-base, forming a small plate. These setae are simple, terminally pointed, but so heavily convoluted that it is difficult to estimate their length; the degree of convolution also tends to give a false estimate of their numbers. (See Fig. 4C). Among them are a few of the long spine-like setae.

Venter of idiosoma is provided with numerous short ciliated hairs, without any spine-like or sword-like setae. Genital valves appear normal, with the usual 3 + 3 oval or circular 'suckers'; the degree of disruption of the specimen precludes further detail being given.

Legs fairly robust (see Fig. 3); lengths (trochanter proximally to tip of tarsus, without claws) I 2 000 μm, II 1 405, III 1 465, IV 1 905. Tarsal claws appear normal. For leg segmental measurements see Table 5 (below).

Gnathosoma as figured. Chelicerae appear normal, but not visible in lateral view, as the right chelicera is at least partly missing (?dissected away). Palp robust. Palpal tibial claw strong, with a strong accessory claw immediately behind it, reaching to about ⅔ its length; another accessory claw behind that also. These two accessory claws are the most distal members of a comb of about 12 spines along the lateral face of the palpal tibia. Similar spines are spread over the lateral face of the palpal tibia, without any regularity of arrangement. (Note: the customary term spine is used here, although these projections are not true spines, but are highly modified normal-type setae, i.e. scobalae.) Palpal tarsus ovoid, shorter than the tibial claw, well-covered with setae, these being longest peripherally, so that these setae extend to reach the level of the tip of the palptibia.

The eggs on the slide are round to oval, or ruptured. The size is quite variable, ranging from about 380 μm x 345 μm, down to 120 μm x 120 μm; an average dimension is perhaps 240 μm x 185 μm.

Site of Origin of the Type of *C. hirsti*

Some clarification is required of the details of the origin of the specimen.

The specimen of an adult in the South Australian Museum collection is labelled TYPE in red ink in Womersley's writing. Other data on the sole slide label are 'Woodside. S.A. July. 1933 M. W. Mules'. The determination of Womersley's on the label is '*Chyzeria australiense* Hirst v. *hirsti* n. v.' I have added 'ACB718'.

Womersley (1934, p. 182) stated that the Type came from 'Willunga, West. Aust.', and lists the Woodside specimen among the paratypes. This is clearly an error by Womersley, as the slide of the Woodside specimen is clearly and unequivocally labelled, and the four slides containing material from 'Willunga, W. A.' have no marking indicating that they were ever considered as type material. The four Willunga slides represent only one specimen, which Womersley had partially dissected. I have labelled these four slides ACB677A-D, for future reference. Although the slides give no date or name of collector on their present labels, which are in Womersley's writing, one slide (A677B, of a palp) has written upon it '(labelled as *C. musgravei* by S. H.', this indicating it was of Hirst's collecting and original identification. No evidence of the original label of Hirst remains. As each slide bears the notation '*Chyzeria australiense* Hirst v. *hirsti* n. v.' (or some abbreviation of this) it is clear that this specimen is to be correctly designated a Paratype.

Slide ACB677D has written upon the label, in Womersley's writing 'Willunga. W. A./ no date/ from Univ. Coll./', indicating that this was one of the specimens deposited by Professor T. Harvey Johnston in the South Australian Museum, from the Department of Zoology, University of Adelaide.

Hirst had worked in the Zoology Department while Professor Johnston was absent in the Antarctic with the British Australian and New Zealand Antarctic

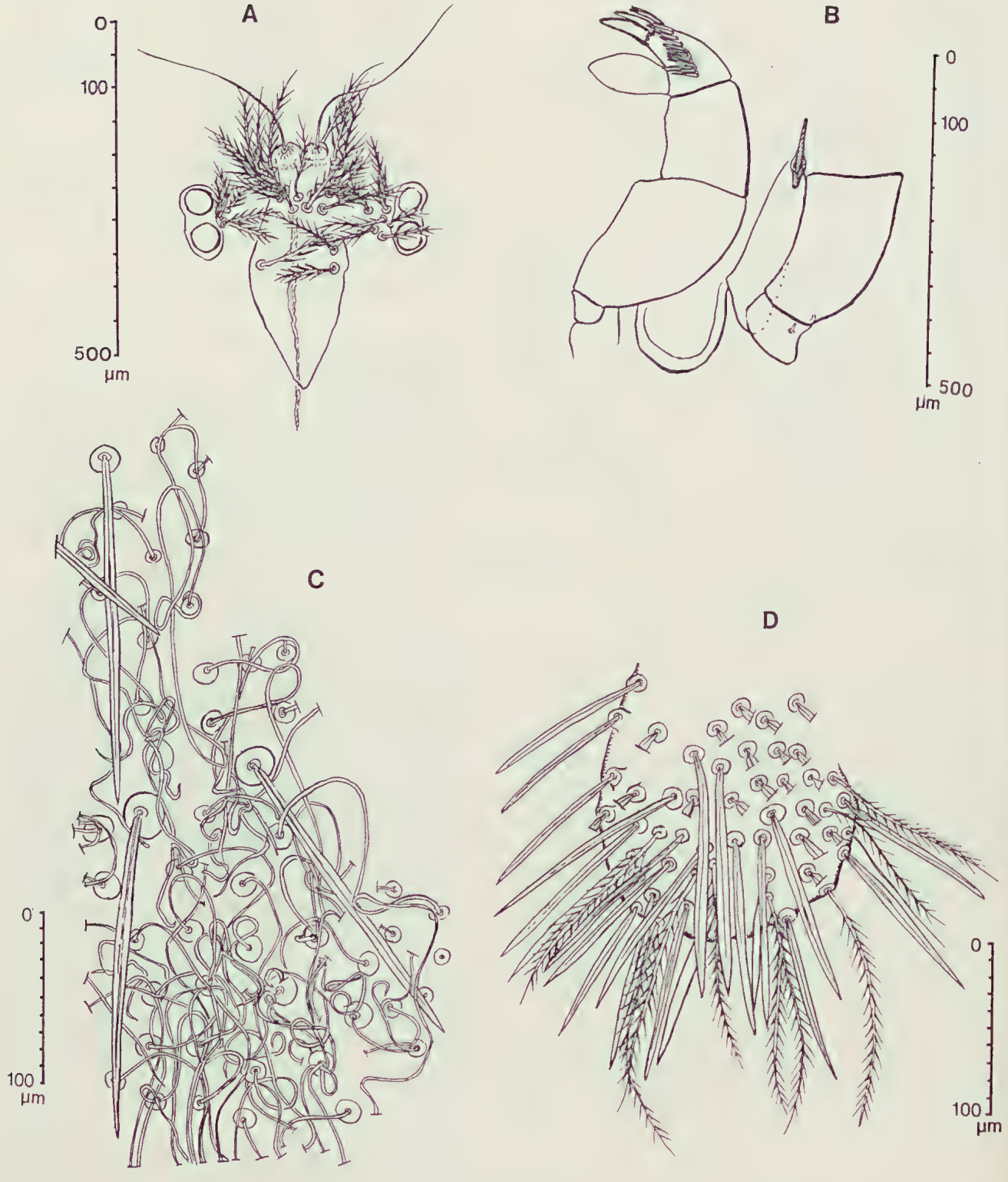

FIG. 4. *Chyzeria hirsti* Womersley, adult. Details of holotype female specimen ACB718. A, Dorsal idiosomal sensilla, eyes and neighbouring structures. B, Left palp, in lateral view, and right chelicera. The left chelicera is missing. The proximal part of the right palp is also shown. C, Setation of the central dorsal part of the idiosoma, showing the fine convoluted sericalae, and a few of the sword-like setae. D, The most posterior of the right lateral column of dorsal idiosomal processes, showing the two types of setae present. (All figures to adjacent scales.).

Expedition of 1929/1931, but unfortunately committed suicide on the return voyage to England. Hirst had collected at various sites in South Australia and eastern Australia, one of his species in fact being named *Microtrombidium willungae* Hirst, 1931* collected by Hirst at Willunga, South Australia, October 1929.

Reference to the Gazeteer of the United States Board on Geographic Names, Number 40 (Australia) shows that the name Willunga occurs only in South Australia, in the forms of Willunga and Willunga Hill, which are in fact contiguous, the former being a township. Both are at 35°17′S lat.; the former at 138°33′E and the latter at 138°34′E long. Womersley arrived in South Australia only in 1933, and at the time was not familiar with South Australian place names (see Southcott, 1963b).

Chyzeria australiense (sic) was described by Hirst in 1928 (1928a, p. 563) from "Swan River, W.A. In nest of *Ponera lutea.*"

In the South Australian Museum collection are four relevant slides labelled as originating from Swan River, W[estern] A[ustralia]. Three of them bear a label in Hirst's writing, while one bears a label by Womersley. These represent the TYPE and a Paratype. I have attached identifying numbers ACB719 and ACB720 to these specimens as follows:

ACB719. Intact specimen mounted in well-slide, labelled in what I interpret as Hirst's writing *"Chyzeria australiense* HIRST/Swan River/W.A./S.A. Mus. Coll./ Nest of *Ponera lutea*"

ACB720. A series of three slides, to which I have attached the identifying numbers ACB720A, B and C, as follows:

ACB720A: Heavily dissected specimen, mounted in well-slide, labelled in same writing as preceding *"Chyzeria australiense* HIRST/Swan River/W.A./S.A. Mus. Coll./Palp", the term "Palp" being crossed out in pencil.

ACB720B: Slide containing the end of a first leg of a trombidiid mite, of three segments, labelled as for preceding slide, but with "1st Leg" replacing the term "Palp". Reference to slide ACB720A shows that three segments are missing from the left first leg.

ACB720C: Slide bearing a label in Womersley's writing *"Chyzeria australiense* Hirst/Palp/ in nest of *Ponera lutea* / Swan Riv. W.A./S.A.M. coll." and has also the word "TYPE" written on it in red ink, in Womersley's writing. This palp appears to have been the source of Womersley's (1934) Fig. 2.

There is no doubt that specimen ACB719 is the Holotype of *Chyzeria australiensis* Hirst, from the red slide notation of "Type", in a writing that does not appear to have been Womersley's, and is presumably Hirst's. I have attached an additional label to the slide, identifying it as ACB719, and with the word "TYPE". This specimen was not figured by Hirst, but was apparently the source of Womersley's (1934) Fig. 1. (The specimen has the palpi flexed, and not extended as figured by Womersley. Otherwise, however, there appears to be a general agreement with the figure.)

The three slides I have labelled ACB720 appear to make up a single specimen, and I have labelled these ACB720A, B and C with additional slide labels, and have added to each the word "PARATYPE". I regard Womersley's use of the word "TYPE" on slide ACB720C as either frankly erroneous, or as a loose indication that the specimen belonged to the type series. I do not know whether there were originally two slides and a further mount was made by Womersley, or whether there were originally three, the label of one being discarded by Womersley in 1933-4.

Some further data and comparisons for adults of *Chyzeria hirsti* Womersley and *Chyzeria australiensis* Hirst.

Table 5 gives various measurements for the holotypes of *Chyzeria hirsti* Womersley and *Chyzeria australiensis* Hirst, as well as for some other specimens of each of these species.

* Now *Ettmuelleria willungae* (Hirst); see Southcott 1957a, p. 142.

Table 5. Measurements (μm) for some adults of *Chyzeria hirsti* Wom. and *C. australiensis* Hirst, including lengths of nominated leg segments and their ratios, also the lengths of the posterior dorsal swordlike setae.

Specimen	*Chyzeria hirsti*								*Chyzeria australiensis*							
	Holotype ♀ ACB718 Woodside, S.A.		Paratype ACB677 Willunga, S.A.		ACB13/14A ♀ Glen Os., S. Aust.		ACB13/14B Glen Os., S. Aust		Holotype ACB719 Swan R., W.A.		Paratype ACB720 Swan R., W.A.		ACB721A Nyabing, W.A. 2.8.45 P.N.F.		ACB721B Nyabing, W.A. 2.8.45 P.N.F.	
	Length	Ratio	Length	Ratio	Length	Ratio	Length	Ratio	Length	Ratio	Length	Ratio	Length	Ratio	Length	Ratio
Segment																
Ta I	605	1.00	583	1.00	572	1.00	562	1.00	482	1.00	482	1.00	580	1.00	576	1.00
Ti I	382	.63	367	.63	396	.69	396	.70	360	.75	396	.82	418	.72	396	.69
Ge I	331	.55	324	.56	346	.60	342	.61	310	.64	313	.65	335	.58	353	.61
Ta II	374	1.00	346	1.00	374	1.00	346	1.00	346	1.00	342	1.00	382	1.00	367	1.00
Ti II	295	.79	259	.75	288	.77	295	.85	288	.83	288	.84	335	.88	324	.88
Ta III	403	1.00	346	1.00	360	1.00	367	1.00	353	1.00	363	1.00	382	1.00	385	1.00
Ti III	317	.79	288	.83	317	.88	317	.86	328	.93	302	.83	367	.96	382	.99
Ta IV	446	1.00	410	1.00	446	1.00	—*	—	389	1.00	389	1.00	432	1.00	439	1.00
Ti IV	468	1.05	400	.98	482	1.08	ca480*	—	482	1.24	493	1.27	562	1.30	522	1.19
Posterior dorsal swordlike setae	80-204		88-172		120-195		144-172		86-135		80-143		72-152		86-138	

* Somewhat obscured in the mount, and cannot be measured accurately

Perusal of Table 5 suggests that some of the dimensions could be useful in separating the two species *australiensis* and *hirsti*. Of them, the range of the lengths of the posterior dorsal swordlike setae is the most useful as the ranges differ considerably, with their maxima ranging from 172-204 μm for *hirsti* and 135-152 μm for *australiensis*.

Chyzeria onychia (Womersley)

(Figs. 5, 6, 7A-B, 8A-G, 9)

Synonymy

Grossia onychia Womersley, 1954 (1954a) p. 111; Audy, 1954, p. 166; Audy 1957 p. 442; Vercammen-Grandjean 1972 p. 231.

Redescription of Holotype

Colour in life not recorded by collector G. F. Gross or by Womersley. Slide-mounted specimen (it has not been remounted by either Vercammen-Grandjean or myself) has the idiosoma ca 1750 μm long by ca 1600 μm wide; total length of animal from tip of chelicerae to posterior pole of idiosoma ca 1900 μm. (The specimen has been severely compressed on the slide and ruptured on mounting, hence these measurements are likely to be significantly larger than the measurements in life.)

The standard (and some other) data of the Holotype are as follows (and compared with data published by Womersley and Vercammen-Grandjean):

	This paper	Womersley (1954)	Vercammen-Grandjean (1972)
AW	96	100.0	97
PW	151	156.0	149
SB	67	73.0	65
ASBa	44	143.0(!)	42
PSB	44	20.0(!)	42
L	88	163.0(!)	84
W	167	—	—
A-P	52, 52	55.0	50
AL	112	112.0	110
PL	83	84.0	88
Sens	ca180	168.0	162
DS	103-173	163	102-174
mid-DS	110-138	—	—
PDS	112-138	—	—

Scutalae tapering, somewhat sinuous in the mount, slightly blunted at tip, with weak, barbed, almost adpressed ciliations.

Eyes 2 + 2, sessile, conjoined, the eye patch placed well laterally to the dorsal shield, eyes of about the same size, anterior more medial, circular, 16 μm across, posterior oval, 15 μm × 17 μm.

Dorsal idiosomalae similar to scutalae, tapering, slightly blunted at tip, with weak, barbed cilia; cilia only a little outstanding from shaft. Dorsal idiosomalae have their seta bases expanded to small plates (see Fig. 8C, D).

Venter: no setae between coxae I, II and III. Behind coxae III are a small number of opisthosomal ventralae, arranged as figured. (The pattern that exists is not clear on account of damage that has been done to the specimen in mounting.) The setae are tapering, pointed, somewhat (more or less adpressedly) ciliated, 40-77 μm long, the more posterior setae the longer (these remarks excluding the most posterior setae of the mount, whose dorsal:ventral relationship cannot be determined from the mount).

Anal region: anus consists of two hinged valves or plates, each 61 μm long by 20 μm wide, hinged ante-

FIG. 5. *Chyzeria onychia* (Womersley). Holotype larva, dorsal view, to scale on left. The specimen has been distorted and ruptured by the mounting process. The anus and surrounding setae cannot be clearly identified as dorsal or ventral in the mount, hence these are repeated in Fig. 6.

riorly and posteriorly to make a structure 44 μm across in the mount. Each anal plate carries two stiff normal setae, almost straight, tapering, slightly blunted; anterior seta 40 μm long, posterior 64 μm. Surrounding the anus is a group of setae similar to last, pointed or slightly blunted. These opisthosomal setae arise from small expanded plates. (The setation over the posterior end of the idiosoma is contiguous between the dorsum and venter, but in the mount its exact position on the idiosoma cannot be determined).

Coxalae 2, 1, 1. Coxalae robust, tapering, somewhat spindle-shaped, curved, with a few adpressed cilia. All coxalae appear to be similar, but in the specimen only the left coxala III is intact, the others being apparently broken, or missing. Coxala III 38 μm long, terminally tapering to a fine point.

Legs as figured; I 560 μm long, II 565 μm long, III 635 μm (from medial point of each coxa to tip of claws). Femoral to tibial segments roughly cylindrical. Tarsus I 129 μm long by 48 μm high, tibia I 92 μm long, genu I 80 μm (TiI/GeI = 1.15). Tarsus III 129 μm long by 34 μm high, tibia III 109 μm long, genu III 85 μm (TiIII/GeIII = 1.29). (Tarsal measurements exclude claws and pedicle.)

Genu I has specialized seta VsGeI.74pd. Tibia I has specialized setae SoTiI.27d, VsTiI.91pd, SoTiI.92d. Genu II has specialized seta VsGeII.71pd. Tibia II has specialized setae SoTiII.23d and SoTiII.83pd. Tibia III has specialized seta SoTiIII.18d.

Tarsal setae as figured. Tarsal pedicles appear normal. Each tarsus is provided with three claws. The middle (neomedian) claw is normal, strong, falciform. Anterior claw reduced to a slender tapering sinuous rod, with a spreading terminal adhesive membrane. Posterior claw is somewhat more robust than the anterior, and straighter; it terminates in a smaller adhesive sucker set an angle to the preceding claw-shaft.

Gnathosoma short, robust. Chelae bases 96 μm long by 48 μm across individually, the two combined being 96 μm across. Chelae blades short, projecting 32 μm beyond the end of the chelae bases. Chelae bases more or less pyriform. Blade with small scattered retrorse teeth on all surfaces, but stronger laterally. Galeala not identified. Anterior hypostomala tapering, pointed with a few adpressed cilia, 45 μm long. Posterior hypostomala similar, 57 μm long.

Palpal formula 0, 1, 1, 3, 9. Palpal femorala robust, tapering, with strong barbs, 74 μm long. Palpal genuala strong, tapering, pointed, terminally filiform, with barbed cilia, 70 μm long. Palpal tibial claw trifid, the three tines tapering, strong, divergent, slightly blunted. Additionally the palpal tibia carries a strong sickle-shaped accessory seta, with a tapering hook-like end and a small tooth about the middle of its ventral side; this possibly operates in apposition to the tibial claw. Palpal tarsus as figured. Palpal supracoxala present, a slender conical seta 9 μm long.

Locality

The specimen is known only from the Holotype. The collector Dr G. F. Gross, has advised me (pers. comm., 4 August 1975) that he collected it at Tambryn Junction, Otway Ranges, Victoria in January 1951. The specimen, which was parasitic upon an adult *Chyzeria*, was probably brought back alive to Womersley.

No *Chyzeria* adult is among the South Australian Museum slide or spirit collection, with locality data for the Otway Ranges, Victoria.

Remarks on Biology

Observations upon a phoretic relationship between *Chyzeria hirsti* and its larvae have been recorded earlier in this paper. When *C. hirsti* larvae were reared in the laboratory, all larvae were small and clearly unfed. In the case of *C. onychia* , the larva is considerably enlarged, and in fact, judging by other experiences of the author with trombidiid larvae, it appears to be at a stage not far away from pupation, even though recorded as attached parasitically. It may seem remarkable that a larva of *Chyzeria* should parasitize an adult of the same genus (and conceivably, of the same species), but among the family Erythraeidae, in some species the larvae will parasitize opportunistically a wide range of hosts including adult erythraeid and anystid mites (see Southcott, 1946 pp. 39, 41).

Remarks on the Generic Status of *Chyzeria onychia* (Wom.)

There does not appear to be any good reason to separate *C. onychia* generically from the other members of the genus *Chyzeria* (the whole of the known larvae) considered in this paper. The body setae are similar to those of other members referred to the genus, and in fact are less aberrant than, e.g., the AL scutalae of *C. hirsti*. The pedocoxalae are in fact the most normal in structure for any of the larvae considered in this paper. The tarsal claws of the legs are also quite similar to those of the other members of the genus. Womersley's erection of *Grossia* appears to have been simply a consequence of his overlooking his earlier (1939) paper, as remarked above.

Chyzeria flindersi sp. nov.

Figs. 10A, B; 11A-D; 12

Description of Larva (from the Holotype specimen ACB674)

FIG. 6. *Chyzeria onychia* (Womersley). Holotype larva, ventral view, to scale on left. Specimen distorted and ruptured (see also legend to Fig. 5).

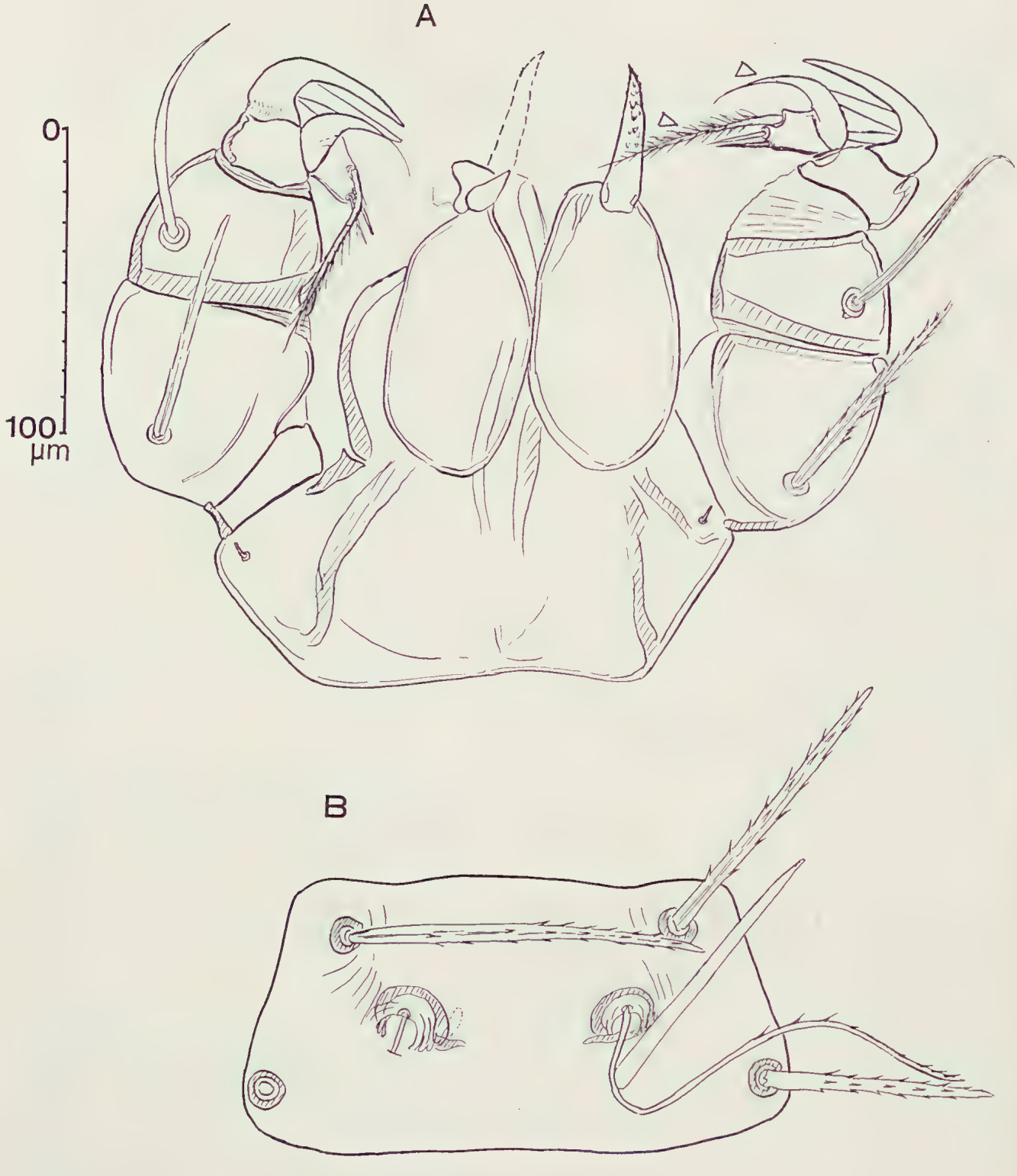

FIG. 7. *Chyzeria onychia* (Womersley). Holotype larva. A, Gnathosoma, dorsal view. B, Dorsal idiosomal scutum. (The right AL scutala has been restored in the figure to its correct position; its position on the slide is shown in outline.) (Both to scale shown).

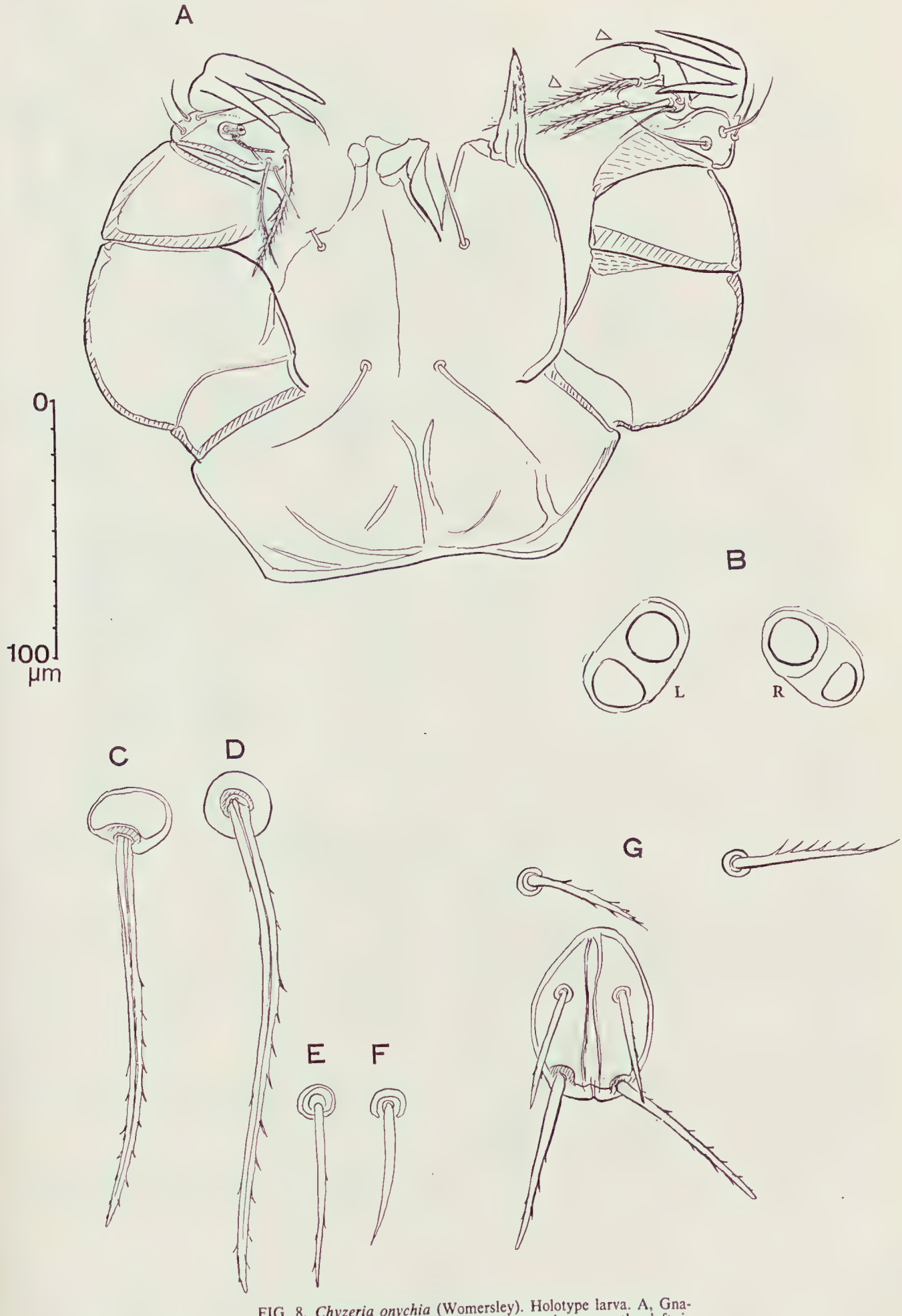

FIG. 8. *Chyzeria onychia* (Womersley). Holotype larva. A, Gnathosoma, ventral view; the chelicera shown on the left is damaged. B, Left eyes and right eyes. C, D, Dorsal idiosomal setae. E, F, Ventral idiosomal setae. G, Anus and surrounding setae. (All to scale shown.).

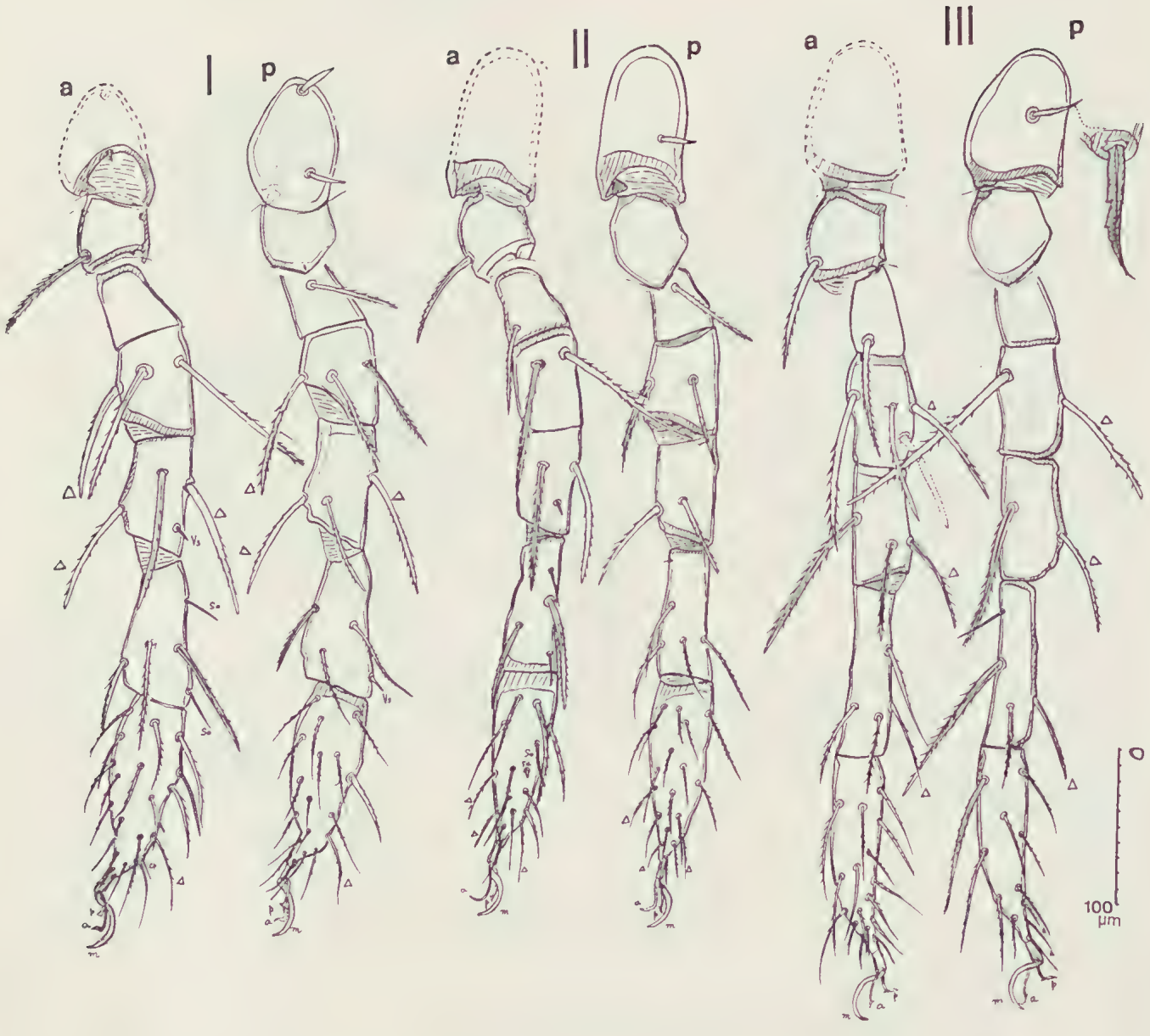

FIG. 9. *Chyzeria onychia* (Womersley). Holotype larva. Legs I, II and III, to scale shown; to standard symbols. (Note: all legs have been dislocated at the trochantero-femoral joints.). Pedocoxala III is also shown, further enlarged.

Colour in life red. Length of idiosoma (mounted on slide) 410µm, width 330 µm; total length of animal from tip of chelicerae to posterior pole of idiosoma 527 µm.

Dorsal scutum as figured; much wider than long, more or less oblong or trapezoidal, with concave anterior and posterior margins, and irregularly convex lateral margins. One pair of scutal sensilla, well separated, placed about halfway between the front and back edges of scutum. AL scutalae at AL angles of shield, PL somewhat anterior to PL angles.

The standard (and some other) data of the Holotype are (µm):

AW	139	A-P	52
PW	184	AL	55
SB	93	PL	52
ASBa	57	Sens	96
ASBp	32	DS	52-77
L	89	Mid-DS	67-71
W	212	PDS	77

Scutalae normal, tapering, ciliated, slightly blunted terminally. Scutal sensillary filaments slender, with a few sparse cilia in distal half.

Eyes 2 + 2, sessile, anterior about 21 µm across, lateral to the posterior part of the lateral edge of scutum; posterior eye close behind anterior eye, 17 µm across.

Dorsal idiosomalae similar to scutalae, but more slender, arranged in rows across dorsum 6, 6, 6, 4, 2, 2; total 26 setae. All dorsal idiosomalae arise from expanded plates.

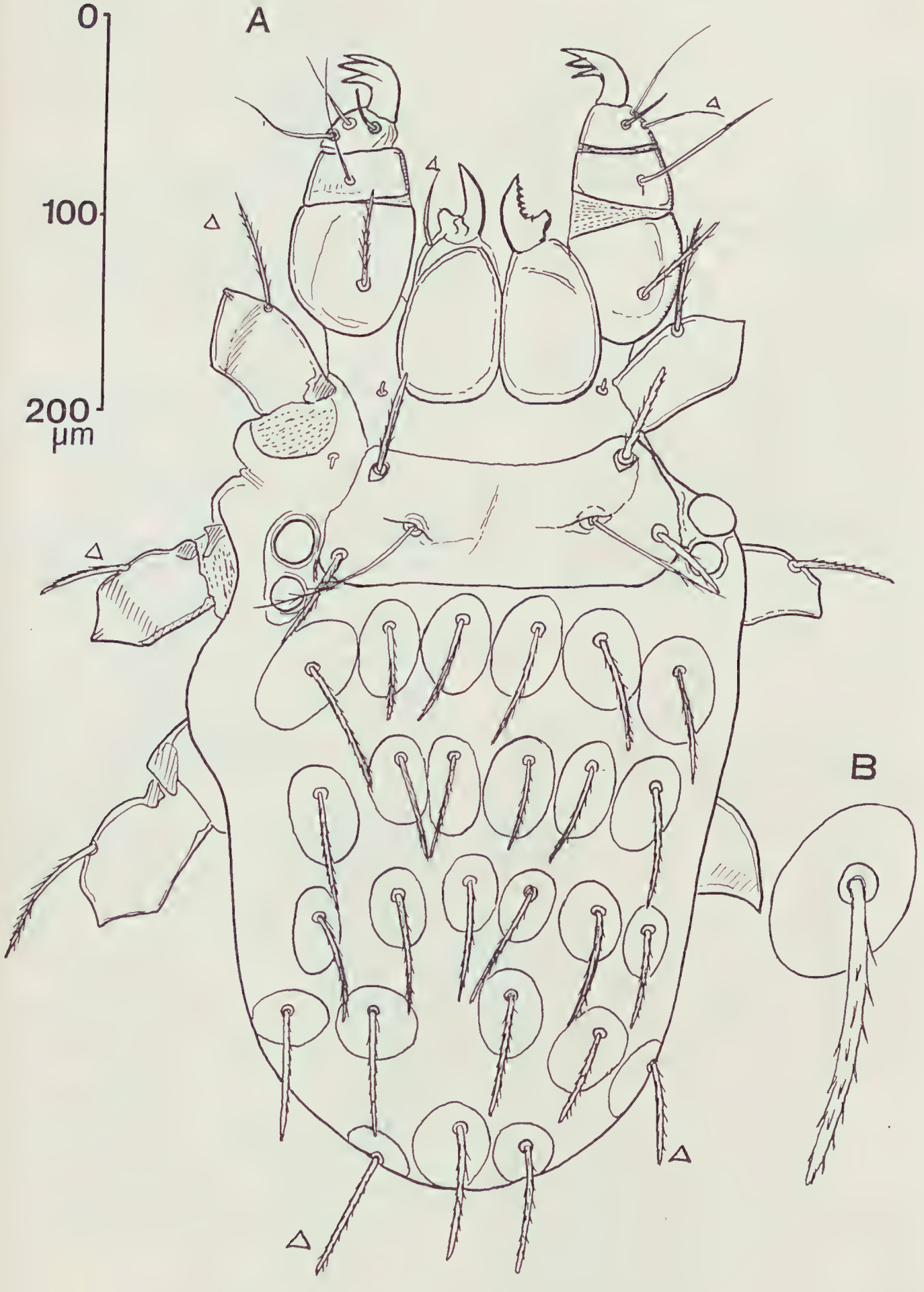

FIG. 10. *Chyzeria flindersi* sp. nov. Holotype larva. A, Dorsal view, to scale on left; legs omitted beyond trochanters. B, Dorsal idiosomal seta, further enlarged.

Venter: no setae between coxae I and II. Between coxae III a pair of setae, with enlarged basal quarter of scobillum, and from this enlarged basal part the distal part arises abruptly, to taper to a smooth point; setae 43, 47 μm long, lacking cilia. Remaining ventralae arise well behind coxae III, about 39 in number, and are 30-54 μm long; they increase in length posteriad. The more anterior setae are similar to the pair between coxae III, except that they carry cilia, these becoming stronger and more outstanding posteriad. The most posterior ventralae tend to resemble the adjoining dorsal setae.

Anal region not clearly visible in Holotype, but appears normal. Anus about 47 μm long.

Coxalae 2, 1, 1. All coxalae stout, blunted, with a terminal slight grooving which makes them appear like small plums projecting from the coxae, 15-17 μm long. Careful microscopy at high power shows an appearance of distal tuberosities (see Fig. 11C).

Legs normal: I 700 μm long, II 655 μm, III 735 μm (all lengths include coxae and claws). Femoral to tibial segments more or less cylindrical. Femora divided. Scobalae normal. Trochanteralae 1, 1, 1, basifemoralae 1 (2), 2 (3), 1, telofemoralae 5, 4, 4. Tarsus I 174 μm long by 50 μm high; tibia I 108 μm long, genu I 94 μ long (TiI/GeI = 1.15). Tarsus III 176 μm long by 40 μm across; tibia III 119μm long genu III 94 μm long (TiIII/GeIII = 1.27). (All tarsal lengths without claws and pedicle.)

Genu I has specialized seta VsGeI.74pd. Tibia I has specialized setae SoTiI.23d, VsTiI.88pd, SoTiI.92d (and hence the distal SoTiI is distal to the VsTiI). Genu II has specialized seta VsGeII.79pd. Tibia II has specialized setae SoTiII.23pd and SoTiII.88pd. Tibia III has specialized seta SoTiIII.26d.

Tarsal setae as figured. Tarsal pedicles short. Pedotarsal claws: anterior curved, slender, two thirds as long as middle claw, with a terminal flattened piece which is more or less at right angles to the claw; middle (neomedian) claw falciform, strong, unciliated; posterior claw curved, slender, shorter than anterior claw, and with a similar flattened transverse piece at the tip (see Fig. 12).

Gnathosoma robust, normal, pear-shaped, chelicera 122 μm long to tip of cheliceral blade, by 108 μm across. Cheliceral blades strong, falciform, 44 μm long. In the Holotype (the only specimen available) the left blade is quite smooth, while the right blade bears ventrally a number of small retrorse adnate teeth; the concave upper surface of the right fang has 7 small teeth, the left fang, none. Galeala spiniform, curved, 33 μm long. Anterior hypostomala short, peglike, 7 μm long. Posterior hypostomala slender, ca 69 μm long, unciliated.

Palpal formula 0, 1, 1, 3, 9. Palpal femorala tapering, slightly ciliated, very slightly blunted, 52 μm long. Palpal genuala slender, unciliated, 71 μm long. Palpal tibial claw (odontus) with three strong, slightly divergent prongs. Palpal tarsalae as figured. Palpal supracoxala a blunted peg, 8 μm long.

Locality

Tasmania: Lake St. Clair, 28 December 1945, R. V. Southcott. One larva, ACB674, Holotype, running up trunk of *Eucalyptus* sp., at about 1.5 m above ground. The site was in fairly open cleared ground, near the shore of the Lake. Type to be deposited in the South Australian Museum.

Nomenclature

This species is dedicated to Matthew Flinders, R. N., 1774-1814, who was the first to survey the major part of the Tasmanian coastline.

Remarks on Asymmetry in the Chelicerae

In the above description an asymmetry in structure of the cheliceral fangs was recorded, one fang (the presumably normal one) being denticulate, and the other smooth. The present author is unaware of a similar asymmetry of the mouthparts having been recorded previously in at least the Trombidioidea, or Erythraeoidea. Among the Erythraeoidea differences in larval shield setation occur at times; for example, see the discussion on this under the account of *Charletonia venus* Southcott in Southcott (1966, p. 709) and for *Charletonia feideri* Southcott (see *ibid.*, Fig. 32, p. 756, and the cases recorded under "Material examined" on pp. 754-8). However, as these setae are presumably responsible for only the sensory input, and some degree of protection, minor abnormalities are unlikely to be a major significance. Major structural abnormalities affecting e.g. locomotory capacity or feeding ability, are more likely to be such a handicap as to threaten survival, and hence are less likely to be encountered in field-collected material.

The specimen was apparently unfed, and whether the asymmetry recorded would be a handicap to feeding is a matter of speculation.

Even among better known animals, major asymmetry in external structures is comparitively rare. Possibly gynandromorphy in insects and heterochromia in mammals are comparable examples. In some groups, notably the fiddler crabs, asymmetry has become part of the genetic inheritance of the group, and is either sex-linked, or hormonally related.

Chyzeria derricki sp. nov.

(Figs. 13A-H, 14A-B, 15)

Description of Larva (from the Holotype Larva ACB633A)

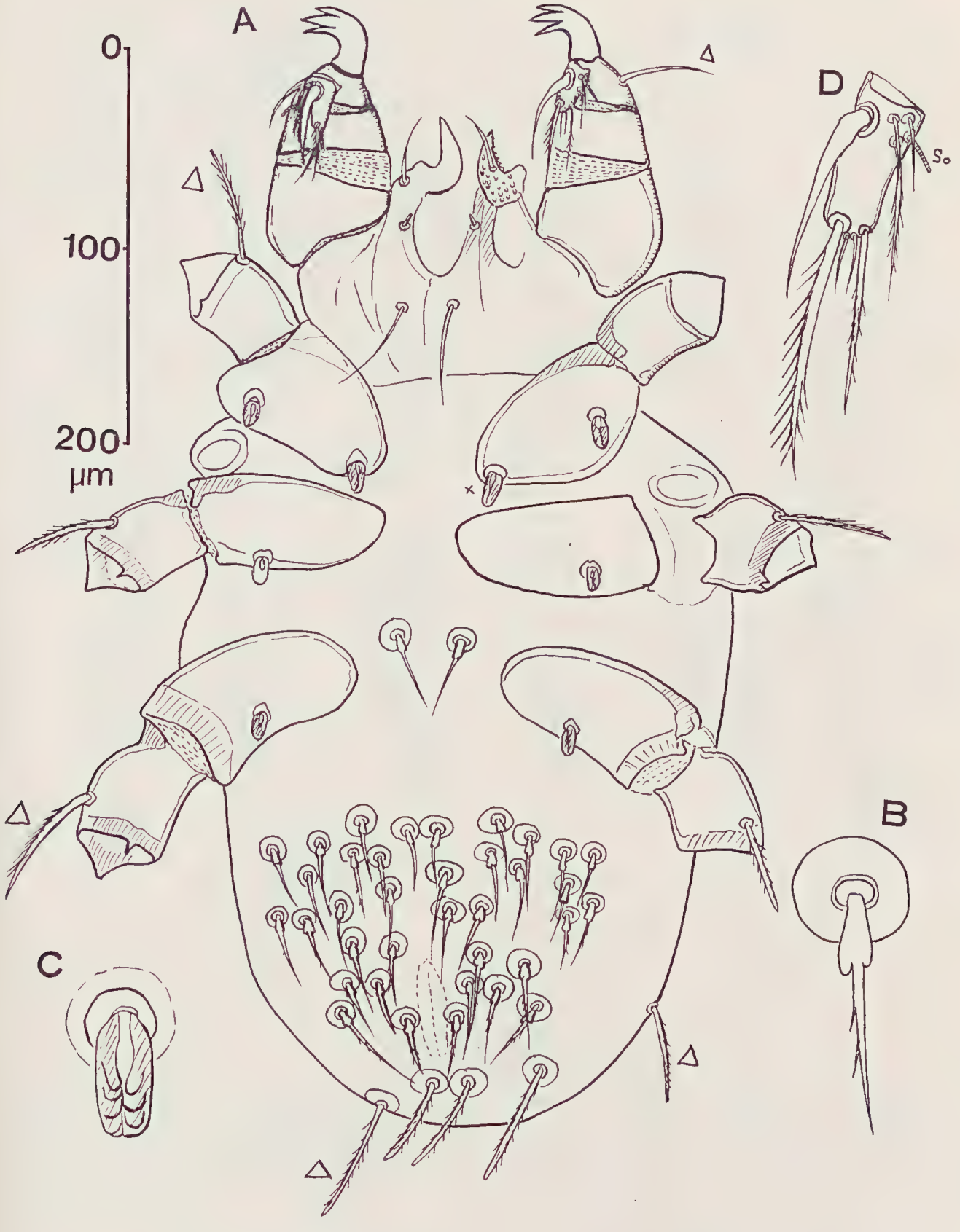

FIG. 11 *Chyzeria flindersi* sp. nov. Holotype larva. A, Ventral view, to scale on left; legs omitted beyond trochanters. B, Ventral opisthosomal seta, further enlarged. C, Pedocoxal seta ('x' in A), further enlarged. D, Palp tarsus, further enlarged.

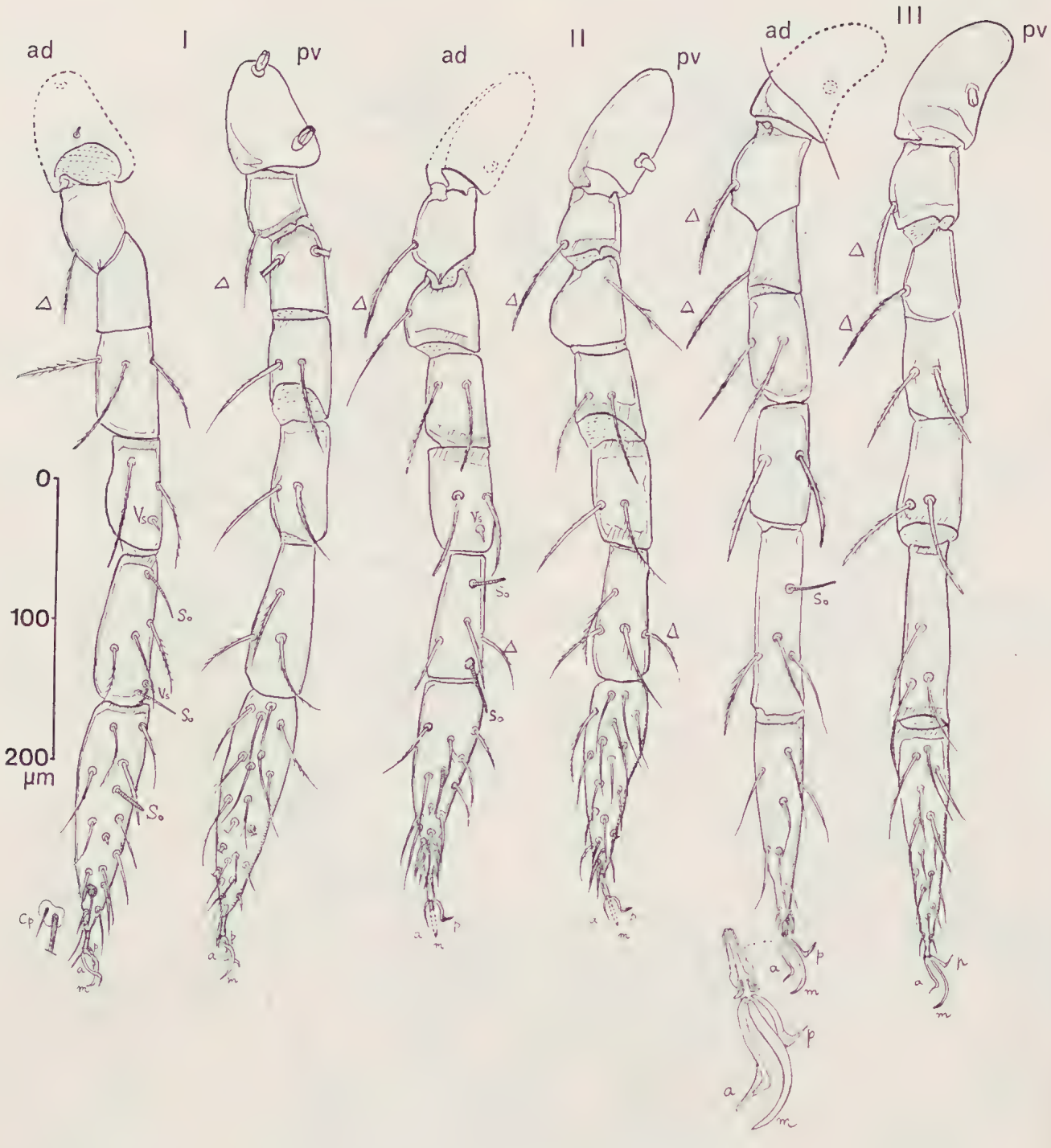

FIG. 12 *Chyzeria flindersi* sp. nov. Holotype larva. Legs I, II and III, to scale on left; to standard symbols.

Colour in life not recorded, presumably red. Length of idiosoma (mounted on slide) 1055 µm, width 610 µm. Idiosoma rather elongate, slightly constricted behind level of coxae III, and somewhat pointed at posterior pole. Total length of animal from tip of galeal seta to posterior pole of idiosoma 1165µm (chelicerae damaged in Holotype, and fangs missing; Paratype ACB 633B lacks gnathosoma, etc.).

Dorsal scutum more or less trapezoidal, with rounded angles, wider posteriorly; anterior and posterior edges slightly sinuous (scutum tends to project a little in the middle posteriorly). Scutum is lightly punctate, particularly in its anterior and more central part, in the area between the sensilla and the AL scutalae. Scutal sensilla normal, the setae with slight, sparse, terminal cilia. Scutalae tapering, pointed, slender, lightly blunted at tip, with adpressed cilia.

The standard (and some other) data of the Holotype (A) and the Paratype (B) are:

	A	B		A	B
AW	102	99	A-P	56, 54	53, 57
PW	152	152	AL	88 (?+)	107
SB	61	61	PL	88	94, 89
ASB	55	55	Sens	153	—

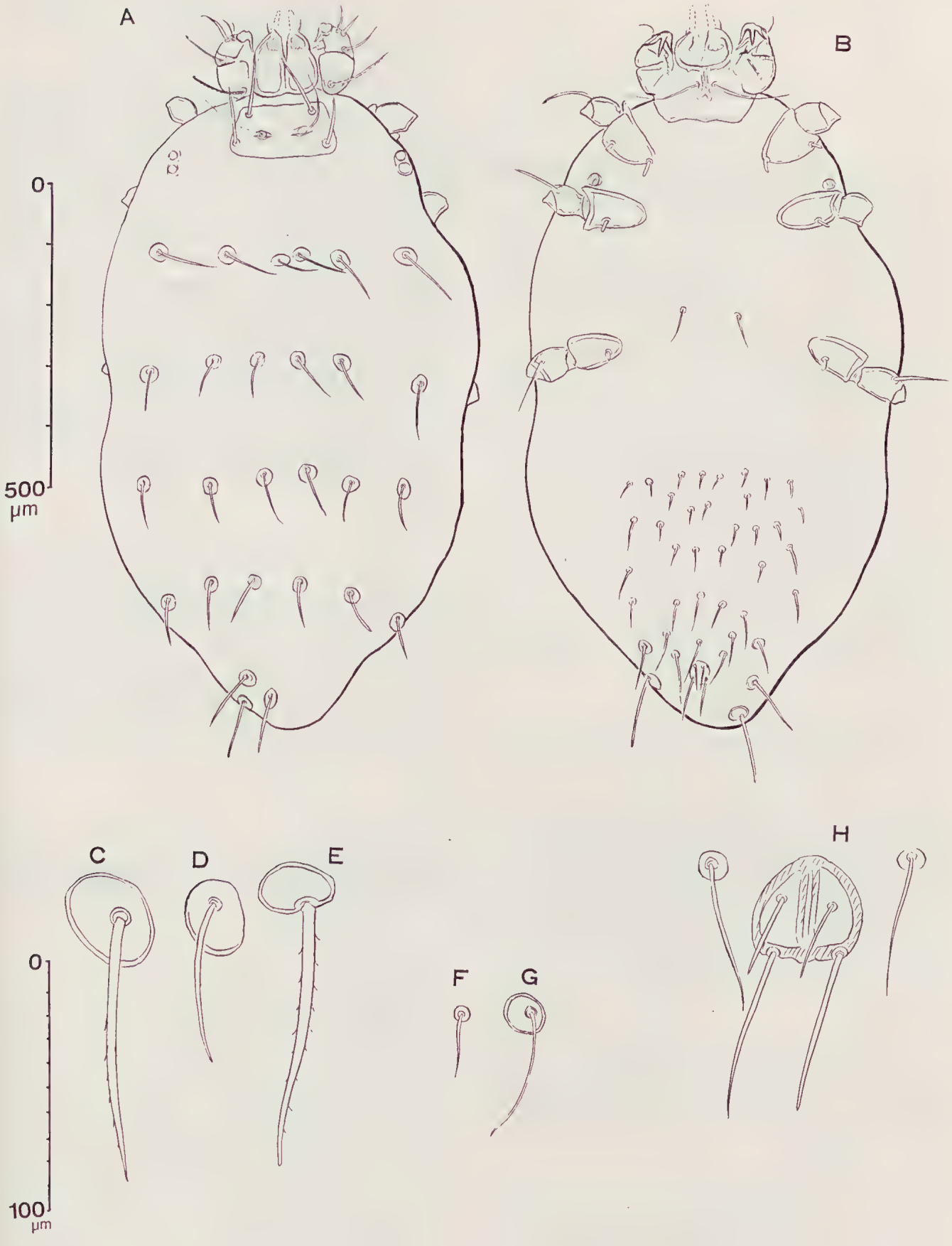

FIG. 13. *Chyzeria derricki* sp. nov. Holotype larva. A, Dorsal aspect, legs omitted beyond trochanters. B, Ventral aspect, legs omitted beyond trochanters. C, D, E, Dorsal idiosomal setae: C, anterior dorsal idiosomala; D, mid-dorsal idiosomala; E, posterior dorsal idiosomala. F, G, ventral idiosomal setae: F, anterior opisthosomala, G more posterior ventral opisthosomala. H, Anal region of venter. (A, B to top scale; C-H to bottom scale.)

	A	B		A	B
PSB	37	39	DS	85-120	74-120
L	92	94	ADS	83-118	77-114
W	178	180	MDS	93-98	74-96
			PDS	85-120	79-120
			PVS	96-114	42-74+

Eyes 2 + 2, sessile, subequal, circular, conjoined, antero-posterior in orientation, lenses 26 μm across.

Dorsal idiosomalae long, tapering, curved, with adpressed cilia, and slightly blunted at the tip; arranged 6, 6, 6, 6, 4, 2. Each seta arises, usually eccentrically, from a small plate, suboval, an expansion of a normal alveolar annulus.

Venter: No setae between coxae I or coxae II. Somewhat anterior to level of coxae III is a pair of tapering, pointed, simple setae, 57 μm long. Behind coxae III is a patch of about 40 similar setae which arise from small plates that increase gradually in size posteriad, with the more posterior setae the longer. The chitinized shaft (scobillum) of the seta also becomes thicker at its proximal end, as one proceeds posteriorad. Anus externally consists of two hinged valves or plates, with a longitudinal opening, the conjoined two making an oval structure 55 μm long by 49 μm wide. Each valve has two setae, tapering, slightly blunted, with adpressed cilia; anterior 48 μm long, posterior 74 μm.

Coxalae 2, 2, 1. All coxalae short, blunted, smooth except for faint distal tubercles (see Figs. 14B, 15). coxalae 15-20 μm long.

Legs comparatively long and thin for a trombidiid larva, compared with body size; tarsi long and terminally attenuated. Leg lengths: I 705 μm, II 655 μm, III 795 μm (all lengths include coxae and claws). Femora divided. Femoral to tibial segments more or less cylindrical. Scobalae of legs tapering, with barbed cilia, and are terminally blunted. Scobalae of telofemora and tibiae tend to be long and particularly outstanding.

Tarsus I 224 μm long by 36 μm high. Tibia I 118 μm long, genu I 112 μm long (TiI/GeI = 1.05). Tarsus III 210 μm long by 24 μm high (at proximal end). Tibia III 141 μm long, genu III 106 μm long (TiIII/GeIII = 1.33). (All tarsal lengths exclude claws and pedicle.)

Genu I with specialized seta VsGeI.82pd. Tibia I with specialized setae SoTiI.10d, SoTiI.91d and VsTiI.92pd. Genu II with specialized seta VsGeII.81pd. Tibia II with specialized setae SoTiII.20d, SoTiII.90d. Genu III without specialized setae. Tibia III with SoTiIII.16d.

Tarsal setae as figured. Pedotarsal claws three in number: anterior slender, falciform with ill-defined terminal spreading suction pad; middle claw falciform, over-reaching others; posterior slender, sinuous, with obliquely placed terminal suction pad.

Gnathosoma short, robust. Conjoined cheliceral bases form a squat pyriform mass 110 μm long (to anteriormost chitinization, except setae) by 105 μm wide. Cheliceral blades missing in Type and Paratype. Galeala normal, pointed, tapering with filiform tip, 32 μm long. Anterior hypostomala not available. Posterior hypostomala long, fine, pointed, simple, about 100 μm long. Palpal setal formula 0, 1, 1, 3, ?9. Palpal femorala tapering, terminally blunted, with outstanding sparse cilia, 123 μm long. Palpal genuala tapering, pointed, unciliated, 96 μm long. Palpal tibialae tapering, pointed. Palpal tibial claw trifid, the three curved tines strongly divergent (see Fig. 14B). Palpal tarsalae as figured, including one relatively huge scythe-like seta, which reaches as far back as the bases of the posterior hypostomalae. Palpal supracoxala short, narrow, pointed, 5 μm long.

Locality

Queensland: Mt Tamborine, 23 February 1954, E. H. Derrick, two specimens taken parasitic upon unidentified tettigoniid grasshopper (identification A294). Holotype ACB633A, Paratype ACB633B (two slides B1 and B2). Specimens forwarded by Dr R. Domrow, Queensland Institute of Medical Research. Type and Paratype to be deposited in South Australian Museum collection. The Paratype has been badly damaged in mounting, and lacks gnathosoma.

Nomenclature

The species is dedicated to the collector, Edward Holbrook Derrick, 1898-1976, medical research worker (see obituary notice in Medical Journal of Australia 6 November 1976).

Remarks on Biology of *Chyzeria derricki*

Parasitization of an insect host is not unusual for a trombidioid larval mite. The only other record of parasitization by a larval *Chyzeria* upon a host is in the case of *C. onychia* (q. v., discussion). The capture of *C. derricki* larva upon a tettigoniid host allows some degree of speculation upon the functional significance of the various morphological adaptations seen in this genus. It is reasonable to suggest, in the case of mites which live as ectoparasites upon mobile insects with wide areas of heavy, smooth chitinization (e.g. Acridoidea and Tettigonioidea), that long legs and development of suction pads upon the tarsi would be useful, as would also strong mouthparts to pierce thickened integuments. On the other hand, it is apparent from a study of at least the erythraeoid mites, that there may be a considerable degree of host specificity, e.g. *Smaris prominens* (Banks) larvae upon

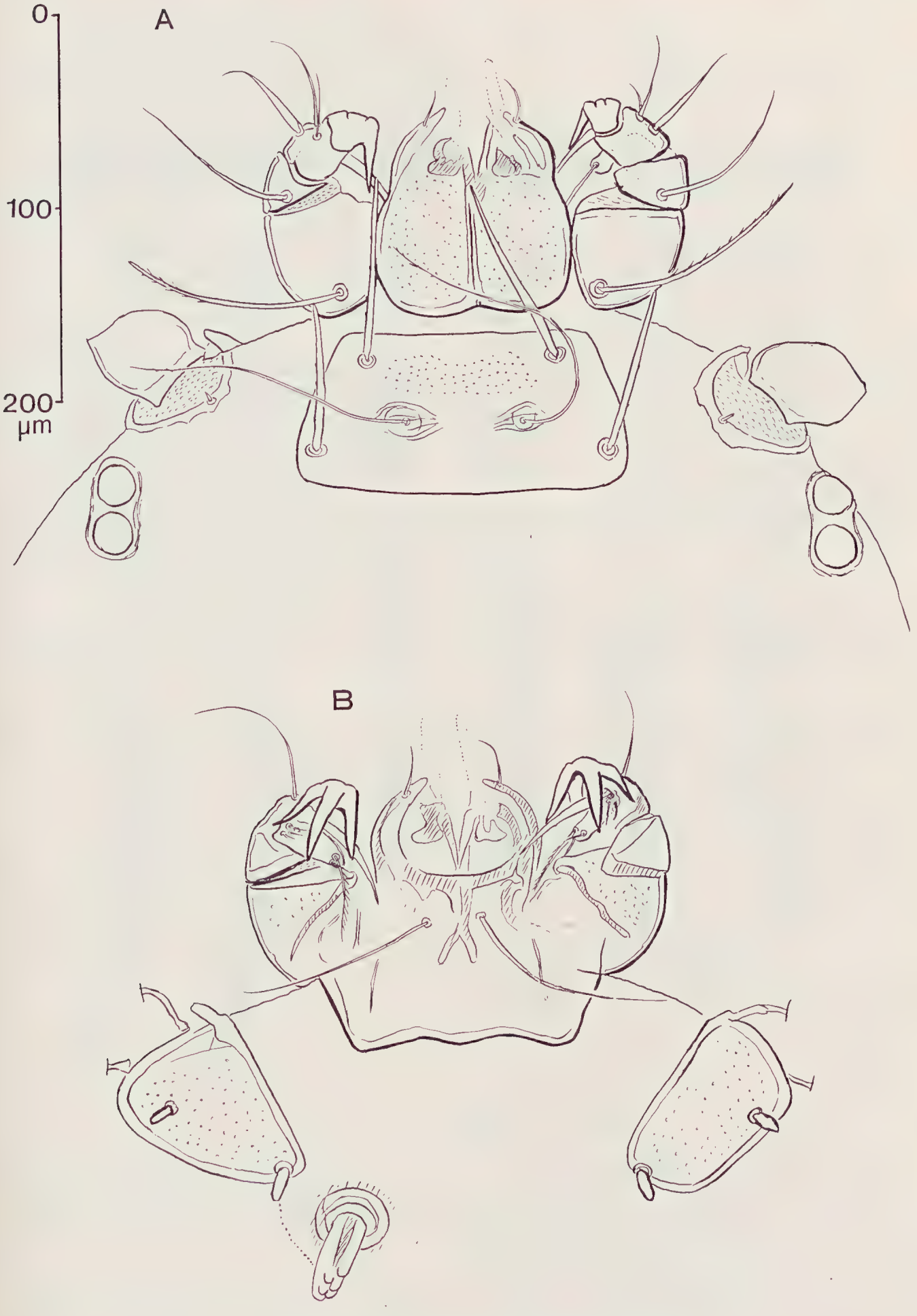

FIG. 14. *Chyzeria derricki* sp. nov. Holotype larva. A, Gnathosoma and adjacent part of idiosoma, and trochanters I, dorsal view. B, Gnathosoma, adjacent idiosoma, with coxae I and part of trochanters I, ventral view. Both to scale shown. In B, a pedocoxala is shown further enlarged.

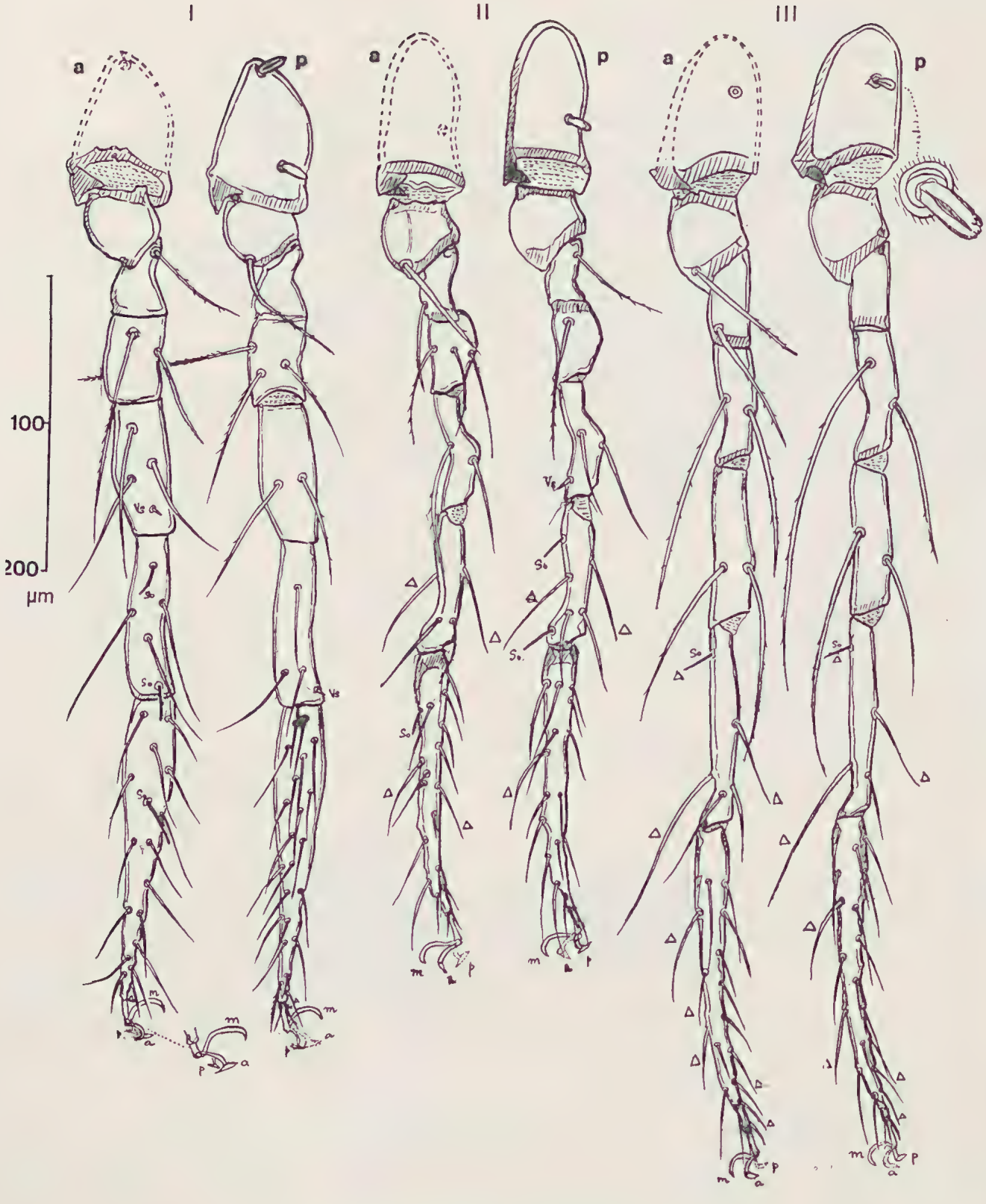

FIG. 15. *Chyzeria derricki* sp. nov. Holotype larva. Legs I, II and III, to standard symbols; to scale shown.

small Psocoptera and *Erythrites osmondensis* (Southcott) larvae upon Thysanoptera. There may also be site specificity upon a host, e.g. *Callidosoma womersleyi* (Southcott) preferring a site under the wings of psyllids, as does also the larva of *Rainbowia imperator* (Hirst, 1928) (Southcott 1961a, p. 477). On the other hand the larvae of other erythraeid mites, *Erythrites reginae* (Hirst, 1928) and *Erythrites urrbrae* (Womersley, 1934), utilize only the external surfaces of the thorax and abdomen and not the under-wing surfaces when parasitizing psyllids and other small insects.

With regard to those members of the Trombidioidea whose larvae utilize insect hosts, in general, there are less systematic data on the range of hosts and the

sites of parasitic attachment than in the case of the Erythraeoidea. This means that at present it is not possible to offer any detailed discussion of the morphological and functional adaptations of these larvae and their adults. This is particularly so where there is some unusual structural modification, such as, for instance, the anterior scutalae of the larva of *Chyzeria hirsti*, or the hind tarsi in the larvae of *Ettmuelleria* Oudemans, 1911 and *Eutrombidium* Verdun, 1909.

CHARACTERISTICS OF LARVAL TROMBELLIDAE

Earlier an attempt at a formal definition for larval Trombellidae was deferred. With the redescription or description of four species of *Chyzeria* in the present paper plus the rearing of *Audyana* Womersley 1954, and with the knowledge that *Trombella* Berlese 1887 and *Womersleyia* Radford 1946 are synonyms, it is proposed to examine what characteristics separate them and the genera *Nothotrombicula* Dumbleton, 1947 and *Ralphaudyna* Vercammen-Grandjean *et al.*, 1974, based on larvae, and also presumed to belong to the Trombellidae, from other trombidioid (or related) mites.

This group of larval trombidioid mites has the following characteristics

(1) coxal formula 2, 1, 1

(2) leg segmental formula:
- *(a)* 7, 7, 7 *Chyzeria; Nothotrombicula; Ralphaudyna*
- *(b)* 7, 6, 6 *Audyana*
- *(c)* 6, 6, 6 *Trombella*

(3) AM scutalae:
- *(a)* absent *Chyzeria; Nothotrombicula*
- *(b)* present as such *Trombella; Audyana*
- *(c)* present as 'presensillae'* *Ralphaudyna*

(4) sternal formula 0, 0, 2

(5) vestigiotibialae 1, 0, 0

(6) vestigiogenualae 1, 1, 0

(7) solenotibialae:
- *(a)* 0, 0, 0 *Chyzeria;* or
- *(b)* 2, 2, 2 *Audyana;* or
- *(c)* 2, 2, 0 *Trombella* (V.-G., 1972)

(8) solenogenualae:
- *(a)* 0, 0, 0 *Chyzeria;* or
- *(b)* 1, 1, 1 *Trombella, Nothrotrombicula;* or
- *(c)* 2, 1, 1 *Audyana;* or
- *(d)* 2, 1, 2 *Ralphaudyna*

(9) tracheae absent

(10) pedotarsal claws:
- *(a)* 1, 1, 2 *Trombella;* or
- *(b)* 2, 2, 2 *Audyana;* or
- *(c)* 3, 3, 3 *Chyzeria; Nothotrombicula; Ralphaudyna*

(11) palpal tibial claw:
- *(a)* trifid *Chyzeria; Nothotrombicula;* or
- *(b)* bifid *Ralphaudyna; Trombella;* or
- *(c)* quadrifid *Audyana*

(12) idiosoma seta-bases:
- *(a)* expanded *Chyzeria; Ralphaudyna;* or
- *(b)* normal *Trombella; Nothotrombicula; Audyana*

(13) scutum 'nasus':
- *(a)* absent *Chyzeria; Audyana;* or
- *(b)* present *Trombella; Nothotrombicula; Ralphaudyna*

Taking these characteristics in order:

(1) This is a characteristic of *Leeuwenhoekia, Odontacarus,* and *Neotrombidium* (Leeuwenhoekiidae); it thus cannot be taken as a definitive character of a trombellid larva, but includes also the leeuwenhoekiids.

(2) Subcharacter 2 *(a)* is possessed by many trombiculid genera, together with *Apolonia, Womersia,* and in fact members of the Erythraeoidea and Hydrachnellae have this characteristic of all femora divided.

Subcharacter 2 *(b),* of having only the first femur divided is possessed by other trombiculids, e.g. *Walchia* (Walchiinae), also *Neotrombidium.*

Subcharacter 2 *(c),* of having all femora undivided, is possessed by the genera *Leeuwenhoekia, Odontacarus, Monunguis* and various others of the Leeuwenhoekiidae; also by *Lassenia* (Johnstonianidae) (see Table 1).

Clearly this character is of no great value at the family classification level.

(3) This is another characteristic which may be present or absent, or present in some degree, and the same occurs with other trombidioids (see Table 1). Similar remarks apply.

(4) This appears to be a constant characteristic. It is also a characteristic of *Leeuwenhoekia, Odontacarus* and *Neotrombidium* (Leeuwenhoekiidae).

(5) Although this character is present uniformly among the genera, it also applies widely among related mites, e.g. *Leptotrombidium, Babiangia* (Trombiculidae), *Leeuwenhoekia* and Neotrombidium (Leeuwenhoekiidae), *Pteridopus,* etc.

It is thus not of much diagnostic value.

(6) This character is also uniform, but occurs also

* Vercammen-Grandjean *et al.* (1974, p. 246)

e.g. in *Leeuwenhoekia* and *Neotrombidium* (Leeuwenhoekiidae), and also in *Pteridopus*.

It also is not of much diagnostic value.

(7) Character 7 *(a)* is shared by *Leptotrombidium, Babiangia, Neotrombidium,* for example. Character 7 *(c)* is shared by *Pteridopus, Polydiscia.*

It is difficult to see how such a widespread and variable character can be considered of much diagnostic use.

(8) It is clear also that character (8), similarly widespread and variable, can be considered of little diagnostic usefulness.

(9) This character is uniform, but also applies to the majority of the trombidioid mites; see Table 1.

(10) It is clear from inspection that the number of pedotarsal claws is in no way diagnostic of the trombellids.

It is apparent also that characters (11), (12) and (13) cannot be used to separate trombellids from other trombidioids.

In a proposal to separate the Trombellinae from the Neotrombidiinae Vercammen-Grandjean (1972, p. 239) proposed the following supposedly differentiating characters for the Trombellinae:

1. a single but trifurcate claw on each anterior and mid leg, two claws on posterior leg tarsus.
2. no microspurs [=vestigialae here] on anterior and mid genu.
3. round urstigma between contiguous anterior and mic [sic, for mid] coxae.
4. uniform porosity on coxae [as against a mosaic pattern over the lateral part of some of the coxae]'.

In 1973 (1973b, p. 109) he used the term Trombellidae, ascribed to Feider (1955), although the term as such appears to have been introduced by Vercammen-Grandjean there. As no formal redefinition appears to have been proposed, it appears reasonable to accept that the characters listed by Vercammen-Grandjean (1972, p. 239) remained as his concept of the differentiating characters of the family Trombellidae, for the larvae. Larval genera accepted by Vercammen-Grandjean (l.c.) as belonging to the Trombellinae were *Womersleyia* and *Audyana.*

If we compare the characters listed above with those discussed in the preceding text of the present article, we find, with respect to character (1) of Vercammen-Grandjean, that with the addition of *Chyzeria* alone to the list the pedotarsal claw pattern may be 1, 1, 2 or 2, 2, 2 or 3, 3, 3 (see my character (10) above).

With respect to Vercammen-Grandjean's character (2), of the possession of a vestigiogenual formula of 0, 0, [0], the formula recorded here is of 1, 1, 0 for all the genera of the Trombellidae considered here, which is the same as the formula for the Neotrombidiinae proposed by Vercammen-Grandjean (*l.c.*), also for *Nothotrombicula.*

With respect to character (3) of Vercammen-Grandjean, above, unless some quantitative measure of ellipticity is to be applied it is difficult to see how such a character can be used. The problem here is not to differentiate the trombellids from the genus *Neotrombidum* and its near relations, but to find one or more criteria which will separate the trombellids from the other trombidioids, at least in the first instance.

For character (4), the presence of a mosaic pattern in the outer parts of coxae I and III in *Neotrombidium* and related genera, this appears to be confined to that group, and is not seen elsewhere among the Trombidioidea.

It would appear therefore that an examination of the available data has not yielded criteria which will allow separation of a larval trombellid with any certainty, although in some cases, where no rearing correlation has been achieved, e.g. for the genera *Nothotrombicula* and *Ralphaudyna,* the resemblances to known larval trombellids are so great that they may be allotted to this family with confidence. At present therefore it is probably justifiable to retain a family Trombellidae, but this has to be based on the adult definition only, and no formal definition of larval Trombellidae can be proposed with any reliability.

This amounts to confirming the view of Robaux (1977b) that, in order to work out the phylogenetic relationships of the Trombidioidea, one cannot rely solely on one aspect of the morphology of these mites, such as that of the larvae or of the adults. In fact Robaux has proposed that biological and ecological factors must also be considered.

Description of a Pygmephorid Mite Phoretic upon an Adult *Chyzeria.*

We now proceed to a description of a species of mite, of the family Pygmephoridae, recorded above as phoretic upon an adult *Chyzeria hirsti* Wom.

Bakerdania workandae sp. nov.
(Figs. 16, 17, 18)

Description of Non-Gravid Adult Female, Holotype ACC226, Mounted.

Colour in life light brown. Length of idiosoma 260μm; length of gnathosoma from tip of chelicerae to posterior superior margin of the cheliceral bases

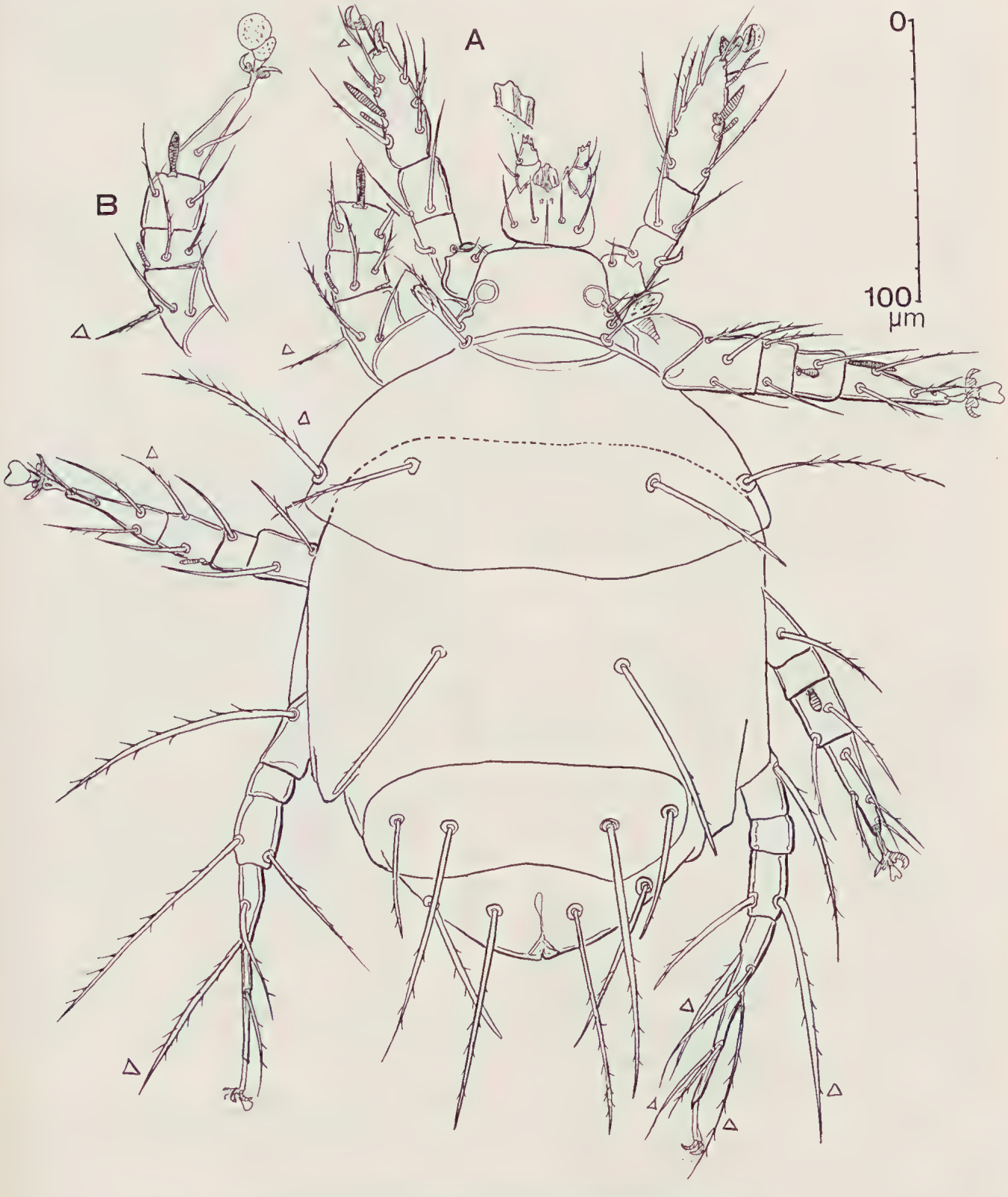

FIG. 16. *Bakerdania workandae* sp. nov. Holotype female. A, Dorsal view. B, Dorsal view left leg II (setae of tarsus II incomplete in B, from obscurity of mount). A, B to scale shown.

28µm; total length of mite from tip of chelicerae to posterior pole of idiosoma 288µm. Width of idiosoma at level of legs III 170µm.

Gnathosoma small, free, subquadrate, 33µm wide. It carries 4 simple spiniform setae dorsally on the cheliceral bases, lateral 23µm long, originate somewhat posterior to medial, which are 20µm long. Ventrally the gnathosoma carries a short spiniform seta (palpal coxala) 14µm long, originating immediately behind the proximal free palpal segment. Both dorsally and ventrally a midline chitinous raphe separates the two gnathobases. Chelicerae small, the stylets not extruded, but confined in the specimen in a small conical cap.

Palpi of two mobile segments. Proximal segment (femur-genu) with a dorsolateral spiniform seta, 11μm long, and distal segment (tibiotarsus) with a similar dorsolateral spiniform seta, 15μm long. Palpal tibiotarsus bears distally a strong broad-tipped tooth, with three or four weakly defined cusps, the lateralmost projecting farthest. Distal segment bears ventrally two solenoidalae, expanded, projecting somewhat anterolaterally. The more posterolateral (solenoidala "1"), about 4 μm long by 1μm wide, is thinner, somewhat clavate; the more medial (solenoidala "2") is larger, 8μm long by 3μm wide, approximately thumb-shaped with an excavated base.

Propodosoma dorsally trapezoidal, widest posteriorly, and with the anterolateral angles rounded; about half as long as wide. Laterally, at about the middle level on each side, is a large circular peritremal opening, 9μm wide, with the centres 37μm apart. Behind and lateral to each peritremal opening is the short anterolateral propodosomal setae, spiniform, 7μm long. Behind and slightly lateral to this seta is the larger posterior propodosomal seta, tapering, pointed, lightly barbed, 29μm long. Behind this, on each side, is a clavate sensillum, 25μm long, by 7μm wide at its thickest part.

Ventral propodosomal setae consist of two more or less transverse rows of 4 setae, total 8; these are tapering, pointed and barbed. The anterior of these arise from the coxal plates ("ventrites") of the first pair of legs. The medial pair of these setae strong, 41μm long, arising at about the middle of the coxal segment; the lateral pair 30μm long, and arise from the cusp between the two leg trochanters ("coxae" of some authors), almost directly below the alveoli of the posterolateral dorsal propodosomal setae. These setae appear as normal type setae, i.e. scobalae, and they are not split or modified in any unusual way. The second row of propodosomal ventralae are similar to the first row; they originate laterally upon a small triangular section of the second coxal plate, at its anterolateral angle, and juxtaposed to the acetabular socket of leg II; medial setae 50μm long, lateral (which is slightly posterior) 52μm long (these two setae are the internal and external ventral setae II of authors). The margins of the circum-gnathosomal foramen are only moderately thickened. Apodemes II transverse. The posterior marginal apodeme of the propodosoma somewhat thickened, more or less linear, running anterolaterally, the two lateral members meeting in a blunted obtuse angle.

Hysterosoma, dorsum: setae long, strong, tapering, pointed, with barbed ciliations. First dorsal pair of setae level with first lateral pair of hysterosomal setae, dorsals 53μm long, laterals 78μm long; dorsals I are 91μm apart. Hind margin of anteromost dorsal plate weakly emarginate. Dorsals II 73μm long, 72μm apart. Dorsals III 91μm long, 59μm apart; laterals III somewhat anterolateral to the dorsals, and 43 μm long. Posterior margin of segment III with distinct smooth median excavation. Dorsals IV ca 90μm long (broken at tip), and centres 28μm apart; laterals IV 63μm long with centres 80μm apart, and a little anterior to dorsals IV.

Hysterosoma, venter: all setae of posterior ventral plate tapering, pointed, with weak barbed ciliations. Medial presternal setae 41μm long with centres 30μm apart, somewhat anterior to lateral presternals which are 53μm long with bases 71μm apart. The latter are a little anterior to the axillary I setae, which are 35μm long with bases 102μm apart. Lateral presternals arise well anterior to apodemes IV, and well lateral to medial presternals. Axillary setae II (arising between the origins of legs III and IV) 53μm long by 98μm apart. Medial poststernal setae are 44μm long by 22μm apart; lateral poststernal setae are 73μm long by 50μm apart. Thus the lateral poststernals are the longest of these setae; and the axillary I setae are the shortest. Apodemes III not clearly defined in the specimen. Apodemes IV are only slightly flexed posteriorly to meet edges of acetabular sockets of legs III. Apodemes V not clearly defined. The posterior margin of the posterior ventral plate is more or less transverse, only a little sinuous. Opisthosoma ventrally entire, with only a minute cleft indicated at posterior pole. The most posterior opisthosomal setae ("caudals") consist of a transverse row of 6 pointed, ciliated setae: lateral pair 19μm long, bases 37μm apart between centres, as usual; the other 4 setae in 2 groups of 2, each lateral group adjoined, the lateral of these 26μm long, medials 32μm long, centres of bases of each pair 3μm apart, the medial of these setae with bases 16μm apart. From the posterior opisthosomal cleft two small "apodemes" diverge in a wishbone-like manner, 17μm long.

Legs as figured. The lengths of the non-fixed part of the legs, to the tip of the tarsal claws, as follows: I 106μm, II 133μm, III 152μm, IV 226μm.

The lengths of the mobile leg segments are as follows (μm) (excluding pedicle and claws in tarsus):

Leg	I	II	III	IV
trochanter*	19	25	33	59
femur	28	34	44	52
genu	18	15	15	14
tibia	56	18	21	27
tarsus	—**	41	37	73

* Cross (1964, 1965) calls this the coxa, and labels subsequent segments accordingly.
** In leg I tibia and tarsus are fused to a single segment.

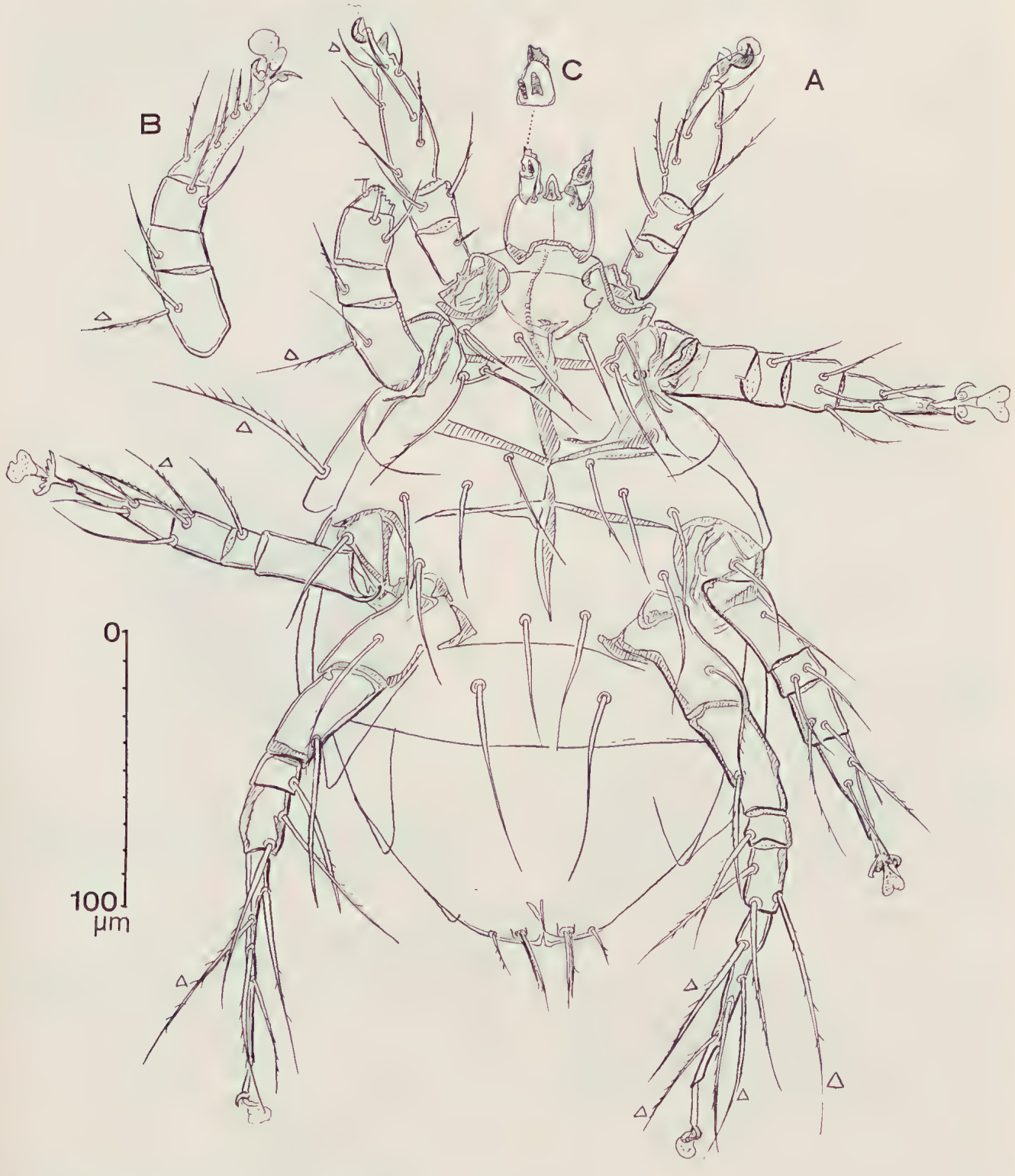

FIG. 17. *Bakerdania workandae* sp. nov. Holotype female. A, Ventral view. B, Ventral view of left leg II (setae of tarsus II incomplete in B, from obscurity of mount). (A, B to scale shown.) C Distal segment of left palp, further enlarged.

The setation formula of the legs is (see Figs. 16, 17):

Leg	I	II	III	IV
trochanter	1d	0	1v	1v
femur	1d, 1v, 1l ('c')	3d, 0-1v	1d, 1v	1d, 1v
genu	2d, 2v	2d, 1v	2v	1p
tibia	8d, 7v +3So	1d, 1l, 2v+So	2d, 2v, +So	2d, 2v
tarsus	—	4d, 4v +So	4-5d, 2v	4d, 2v

Details of leg specialized setae are as follows:

Leg I. The tip of 'seta c' of femur I (a modified scobala) somewhat falciform and sharply proflexed. On dorsum of tibiotarsus I are two expanded solenoidalae, and more distally one attenuated solenoidala, and more distally again a retroflexed sensory seta; at the "proral situation" a further seta, probably a solenoidala.

Leg II. On tibia II the proximal end is overlain dorsally by a stout clavate solenoidala. On tarsus II a similar clavate solenoidala lies dorsally and proximally.

Leg III. On tibia III a clavate solenoidala arises proximally and dorsally.

Tarsal claws: On leg I single, on a short pedicle, and the tibiotarsus I distally and ventrally carries a short "thumb-process". On tarsi II-IV the claws are double, each claw strong, falciform, and with a basal tuberosity or "cushion"; the middle (neomedian) claw has a chitinized wishbone-like basal piece, from which an adhesive membrane spreads out fanwise, lobate.

Material Examined

Holotype specimen, ACC226, to be deposited in South Australian Museum collection. Taken attached to central dorsal area of adult *Chyzeria hirsti* Wom., specimen ACB320, from under stone, Workanda Creek, National Park, Belair, South Australia, 1 August 1948, R. V. Southcott.

Notes on Behaviour

On capture the adult *Chyzeria hirsti* was examined under a binocular microscope to see if it carried any larval *Chyzeria*. None was observed. I recorded "To my surprise I found a small brown mite in the cavity of its back as shown [see Fig. 18]. . . It was cleaning the back part of the abdomen by hooking its last pair of legs over, in the same way as a fly does".

The relationship between the adult female pygmephorid mite and the adult *Chyzeria hirsti* is presumably best described as a phoretic one. The relationship is unlikely to be a parasitic one in view of the small size of the cheliceral stylets of pygmephorids, and the fact that the pygmephorids, in a restricted sense, are not known to be parasitic; a number of species are now known to be fungus-feeders (see e.g. Wicht (1970), Kosir (1975) and the further references they quote).

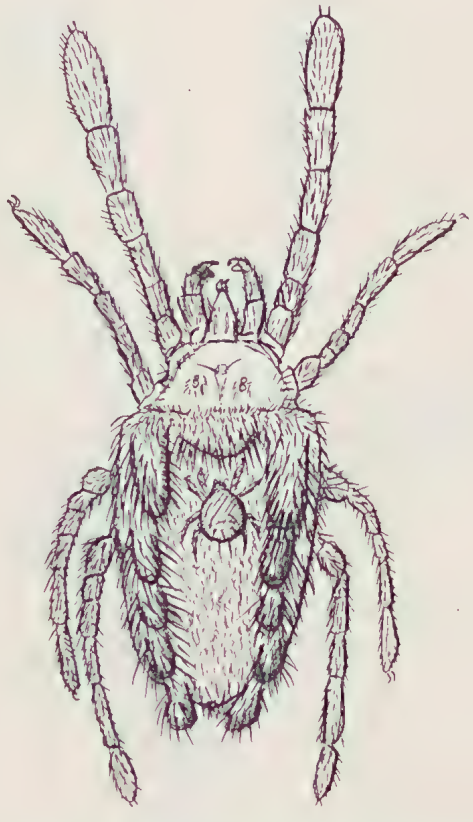

FIG. 18. Adult male *Chyzeria hirsti* Womersley carrying an adult female pygmephorid mite, the holotype of *Bakerdania workandae* sp. nov., in the space on the dorsum between the dorsal idiosomal processes. From life, redrawn from a sketch made at the time.

As a phoretic host, it would appear that the adult *Chyzeria hirsti* is not likely to be efficient. Although *Chyzeria hirsti* adults are, among similar-sized soil-inhabiting Australian adult trombidoid mites, relatively fast-moving, it would seem unlikely that they would disperse over other than small distances.

Remarks on Classification

In the systematic placing of *Bakerdania workandae* I have been initially guided by the works of Krczal (1959) and Cross (1964, 1965). Cross produced a monographic revision of the genera of the Pyemotidae *(sensu lato)*, and this was to have been followed by a first application of the revision to localized faunas. The large monographic revision was published as Cross (1965) and contained a division of the old genus *Pygmephorus* Kramer, 1877 into the new genera *Acinogaster* Cross 1965, *Parapygmephorus* Cross 1965, *Pseudopygmephorus* Cross 1965, and *Neopygmephorus* Cross 1965, as well as a number of subgenera. Cross applied these names in his paper studying

the relevant mite fauna of Macquarie Island, which appeared earlier as Cross (1964). By then he had reached the conclusion that the separation of the genera named might not be entirely valid, as the Macquarie Island survey immediately revealed species with characters belonging to one or more of the genera proposed. In response to this he placed the five Macquarie Island species in *Neopygmephorus*, with the comment that "In the above paper [Cross, 1965], I divided the tribe Neopygmephorini into four new genera .... Acquisition of new material since then indicates that this grouping is probably unjustified, and that it is more realistic to join at least *Pseudopygmephorus* and *Neopygmephorus* ....". Of the two last-named generic names, *Pseudopygmephorus* has page priority, but Cross (1964) presumably chose to use the name *Neopygmephorus* on the ground that a tribal name was based upon it, although this is not stated.

Subsequently Cross (1970) has shown that *Neopygmephorus* is a junior synonym of *Bakerdania* Sasa 1961, and this has been accepted by other workers on the Pygmephoridae and Pyemotidae, e.g. Mahunka (1973a, b), Rack (1974).

A further complication has since been discovered which may have an important bearing on the generic placing of "pyemotid" mites. This is the observation that in certain of the pygmephorid and pyemotid mites the adult females may appear in two forms, the phoretomorph and the non-phoretomorphic forms, which have different generic placements in existing classifications, e.g. *Siteroptes* and *Pediculaster*, or *Siteroptes* and *Pygmephorellus* (Rack 1974; Cross and Moser 1965; Moser and Cross 1975). So far this phenomenon does not appear to have been recorded with those pygmephorid mites allotted to the generic forms proposed by Cross in 1965, but clearly this possibility cannot be excluded.

In recent years no full revision of the Pygmephoridae and Pyemotidae has been published*, and at present the only general work on the pygmephorids and pyemotids of the world is by Krczal (1959). In this latter the old genus *Pygmephorus* Kramer 1877 was not divided into subgenera. By Krczal's key the species described above comes to the caption of *Pygmephorus kochi* Krczal 1959, from which there are a number of morphological differences. Among these are the more spindle-shaped tibiotarsi I, the presence of a strong opposition-piece (anvil, or *incus*) to the claw of tibiotarsus I, the far more elongate tarsus IV (three times the length of tibia IV, as against twice in the case of *P. kochi*) and a number of other factors. *P. kochi* was one of the 16 species or subspecies placed by Cross (1965, p. 224) tentatively in his genus *Pseudopygmephorus*.

By the generic table of Cross (1965) the species described above comes within *Neopygmephorus* Cross 1965, subg. *Neopygmephorus*. Cross (1965, p. 230) gave a list of the already described "pyemotids" which he believed should be placed in this subgenus, amounting to 17 species and one subspecies, but did not submit a diagnostic key to separate them. The only recent key to a group of related pyemotid mites from the Australian region known to the present author is Cross's (1964) study of the fauna from Macquarie Island, allotted to *Neopygmephorus*. These indicate the wide-spread distribution of these mites, as species known hitherto from Europe, Japan and North America were represented.

Accepting that the species described above belongs to *Neopygmephorus* as used by Cross in his 1964 paper, i.e. to *Bakerdania* Sasa 1961, and using that key, one finds that *B. workandae* comes closest to *B. arvorum* (Jacot 1936), originally described from North America by Jacot (*l. c.*) but now known to occur also in Macquarie Island (Cross 1964), Germany (Rack 1967), Jugoslavia (Mahunka 1975b) and Tunisia (Mahunka 1978) and to *B. togata* (Willmann 1942), originally described from Germany, but now also recorded from Macquarie Island (Cross 1964), Hong Kong (Mahunka 1975a) and Africa (Mahunka 1976). Rack (1967 p.10) places *P. arvorum* Jacot, 1936 in *Pseudopygmephorus* Cross, as did also Cross (1965, p. 224).

From these two species *B. workandae* may be separated as follows:

B. workandae has 6 caudal setae instead of the 4 which occur in *B. arvorum*.

B. workandae has the lateral presternal setae well lateral to the medial presternals, while in *B. togata* the lateral presternal setae are only slightly lateral to the medial presternals. In *B. workandae* the lateral poststernal setae are significantly longer than trochanter IV, while in *B. togata* the lateral poststernals are significantly shorter than trochanter IV (see further in Cross 1964; Willmann 1942).

A number of papers have been written on the pyemotid fauna of the world since the acceptance of the status of *Bakerdania* as a senior synonym of *Neopygmephorus;* some of these describe new species of *Bakerdania*. Of the new species described, in the literature available to me from the extensive reprint library of the South Australian Museum, and in my own and other libraries, there is only one which appears to have a significant resemblance to *B. wor-*

*In recent years further taxonomic changes at the family and suprafamilial levels have been introduced for these mites. Thus the superfamily names Pyemotoidea and Pygmephoroidea have been used by some authors (see further in Krantz, 1978). These taxonomic changes are, however, outside the scope of the present work.

kandae sp. nov. This is *B. discrepata* Mahunka, 1973, from Ghana (1973b, p. 318). Both of these species are known from only a solitary female; males are unknown for them. These two females may be separated as follows:

Tarsus IV (excluding claws and pedicle) less than twice as long as tibia IV. Tibiotarsus I short, ellipsoidal. Distal solenoidala on tibiotarsus I short, about half as long as the immediately proximal thick solenoidala . . . *B. discrepata* Mahunka 1973

Tarsus IV (excluding claws and pedicle) more than twice as long as tibia IV. Tibiotarsus I spindle-shaped. Distal solenoidala of tibiotarsus I long and attenuated, longer than the proximal thick solenoidala . . . *B. workandae* sp. nov.

Acknowledgement

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SARCOPTIFORMES (ACARI) OF SOUTH AUSTRALIAN SOILS.

3. ARTHRONOTINA (CRYPTOSTIGMATA)

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ABSTRACT

LEE, D. C. 1982. Sarcoptiformes (Acari) of South Australian soils. 3. Arthronotina (Cryptostigmata). *Rec. S. Aust. Mus.* **18** (15): 327-359.

A study of sarcoptiform mites from surface soil (usually greatest depth = 4 cm) at 9 florally diverse sites in South Australia is continued. Notations for hysteronotal fissures, kinds of gnathosoma, solenidia, form of notal setae and shield sculpturing are presented. Comments are made on the systematics of Macropylides in which the disbanding of the cohort Ptyctimina is supported. The included Arthronotina are divided into 3 new subcohorts: Monofissurae, Retrofissurae and Profissurae. A new family, Trichthoniidae, is established. A new name, *Neoliochthonius,* is given to *Paraliochthonius* Moritz not the pseudoscorpion genus *Paraliochthonius* Beier. New diagnoses are given for some superfamilies, families and genera. In this study, 11 species were collected. Two species are new: *Gehypochthonius strenzkei, Verachthonius moritzi.* Six species are newly recorded from Australia: *Hypochthoniella minutissima* Berlese, *Brachychochthonius elsosneadensis* (Hammer), *B. cricoides* Weis-Fogh, *Trichthonius pulcherrimus* (Hammer), *Phyllozetes emmae* (Berlese), *Sphaerochthonius splendidus* (Berlese). Three species were previously recorded from South Australia: *Cosmochthonius australicus* Womersley and 2 which were misidentified; *Liochthonius simplex* (Forsslund) as *"Brachychthonius* cf. *perpusillus", Liochthonius fimbriatissimus* (Hammer) as *"Brachychthonius* cf. *horridus".* The descriptions of 4 species not collected in this study are extended: *Gehypochthonius rhadamanthus* Jacot, *Hypochthoniella borealis* Jacot, *Poecilochthonius parallelus* (Womersley), *Liochthonius longipilus* (Womersley). *Cosmochthonius wallworki* and *Sphaerochthonius wallworki* are established for *"C.* sp." Wallwork and *"S.* sp." Wallwork. The synonymy of *Cosmochthonius domesticus* under *C. lanatus* by van der Hammen is revoked. Three subspecies of *Cosmochthonius* are given species status. New combinations are *Gehypochthonius urticinus* (Berlese) (ex *Parhypochthonius), Poecilochthonius parallelus* (Womersley) (ex *Brachychthonius), Liochthonius longipilus* (Womersley) (ex *Brachychthonius), Verachthonius montanus* (Hammer) (ex *Eobrachychthonius)* Besides 2 new identifications above, *Liochthonius ocellatus:* Hammer, 1958 is identified as *L. longipilus* (Womersley).

INTRODUCTION

This publication is part of a previously introduced study (Lee 1981) in which I indicated that I would follow Balogh's (1972) classification. However, although that classification is valuable because of its comprehensive nature, in dealing with the Macropylides or "Primitive Oribatei" it ignores parts of the published work of Grandjean and van der Hammen. In doing so it retreats from maturing the classification. Therefore, although this paper is primarily concerned with the Arthronotina, it includes a systematics section on the Macropylides in order to explain the higher classification used here, which is a modification of that presented by Grandjean (1969). Furthermore, higher taxa are given endings similar to those of Krantz (1978) in order to standardize the differentiation of each level. It should also be noted that, contrary to common practice amongst acarologists, other zoologists follow Simpson (1945) in regarding a cohort as a category between class and order rather than between order and family.

In order to examine the optical activity of some hairs, the Leitz microscope and interference contrast device T normally used was modified for use as a polarizing microscope by having a bright-field condenser disc and objectives so that no Wollaston prisms were in the beam path.

All material collected in this study is deposited in the South Australian Museum, Adelaide, unless stated otherwise.

NOTATION FOR MORPHOLOGY

The notation followed is as previously presented (Lee 1981), but comments are made below on the notation for hysteronotal fissures and shields, kinds of gnathosoma, solenidia, form of notal setae and shield sculpturing.

Hysteronotal Fissures and Shields

On most adult Cryptostigmata the hysteronotum is covered by a single continuous shield. The Arthronotina are unusual in that this integument is broken up into a series of shields separated by striated cuticle which when it forms a narrow strip is referred to as a fissure. In a description there is often a bias towards describing one or the other. Descriptions of the dorsal integument of Arthronotina are mainly biased towards

describing the transverse fissures. On the other hand, the lateral integument is usually described in terms of its shields. The latter can be confusing because a shield may be described as absent either because it is replaced by striated cuticle or because it is still present but is not separated from the rest of the notal shield by a fissure. The notation to be used is considered under two headings: *(a)* fissures, *(b)* shields (see also Fig. 1).

(a) Fissures. The signature "B" (initial letter of "break", "F" having already been allotted) will be used for a line separating one part of a shield from another part that is either a strip of striated cuticle or is regarded as representing what was a strip of striated cuticle in some allied species. Fissures are regarded as belonging to 5 categories: (i) *acutely hinged fissures,* with articulated sides capable of movement from a level position to enclose an angle of 80° to 140°; (ii) *hinged fissures,* with articulated sides only capable of movement to enclose an angle of 140° to 175°; (iii) *complete fissures,* with immovable sides completely dividing a shield into separate parts; (iv) *partial fissures,* not completely dividing shield into separate parts; (v) *relict fissures,* no strip of striated cuticle, but some demarcation furrow on shield representing a fissure. The taxonomically important fissures are the *transverse hysteronotal fissures* of which there is a maximum of 3 (*TB*1, *TB*2, *TB*3) each lying behind the same numbered seta in hysteronotal file *J*. There may be transverse lines behind seta *J*4 but these are not regarded as representing strips of striated cuticle. Only one lateral hysteronotal fissure is referred to: the *dorsolateral longitudinal fissure* (LB). This separates what are called pleural shields from the notal shields.

(b) Shields. On the hysteronotum there are a maximum four *notal* shields (*NS*1-4) and four *subnotal shields* (*SNS*1-4) numbered from the anterior. The subnotal shields have been referred to as "suprapleural" shields (Moritz 1976) but, since they sometimes merge with the notal shields as for example shield *SNS*1 which bears seta *S*1, I have preferred to relate them to the notal shield. Ventral to the dorsolateral longitudinal fissure are the *pleural shields* (*PS*1, 2) and *subpleural shields* (*SPS*1, 2).

Kinds of Gnathosternum

The 3 parts of the gnathosternum which contribute to its general shape are the palp coxites, external malae and mentum. In a few groups there is no mentocoxal fissure so that the precise border between the mentum and the palp coxites is not known. Grandjean (1957) regarded gnathosterna as belonging to 3 basic kinds (anarthric, stenarthric and diarthric), but I have found it more useful to directly describe the structures involved.

The following notation is introduced to describe the external malae and mentum. *Disjunct external malae* are well separated and lie either laterad or dorsolaterad to the internal malae and the bases of the preoral setae. *Conjunct external malae* lie ventrolaterad to the internal malae and the bases of the preoral setae, whilst a ridge indicates that the protruding parts of the palp coxites from which they originate come together midventrally behind the internal malae. *Coarctate external malae* abut ventrad to the preoral setae, obscuring them from view. An *undelineated mentum* has no distinct border with the palp coxites because there is no mentocoxal fissure, although, when this is true for members of the primitive beetle mites, the mentum is probably triangulate and sometimes ridges suggest its outline. A *triangulate mentum* is almost triangular in outline coming gradually to an anterior apex. The lateral margins lie well behind both this apex and the coxotrochanteral joint of the palps. A *quadrangulate mentum* is almost square or rectangular in outline, usually with a straight, transverse anterior margin. This shape results from a thickening of the lateral margins of the mentum so that its anterior shoulders move forward close to the coxotrochanteral articulation of the palps.

A general statement can be made that the gnathosterna of Cryptostigmata have evolved from those with disjunct external malae and an undelineated mentum to those with coarctate external malae and a quadrangulate mentum. The Arthronotina have either disjunct or conjunct external malae and an undelineated mentum.

Solenidia

Three of Grandjean's established terms for solenidia of certain shapes (*baculiform, ceratiform* and *piliform*) (see Norton 1977) are used below. The term "tactile" is replaced by *flagelliform* and the term *spiniform* is used for stout evenly tapering solenidia. Some solenidia are *coupled* with a seta, occupying the same alveolus, whilst others are either *associated* with a seta or well *separated* from any seta.

Although solenidia are usually dorsal, either 1 or 2 ventral solenidia have been recorded (Grandjean 1954b 1963, Covarrubias 1968, Reeves and Marshall 1971) on the tarsus I of some Brachychthoniidae, Protoplophoridae and Sphaerochthoniidae. In describing a new species of *Verachthonius* below these solenidia were examined with polarized light and appeared to fit the definition of solenidia, but are spiniform, which is not a shape found amongst dorsal solenidia. The symbol *sov* is used for these solenidia, and if in a pair the anterior one is numbered first.

Form of Notal Setae and Shield Sculpturing

In identifying the *Cosmochthonius* species collected in this study it was found that some attributes of the form of the notal setae and shield sculpturing had to be carefully delineated since these characters, which may be trivial and inaccurately described in some previous descriptions, had to be used because few other data were available.

In describing the long hysteronotal setae, seta *J*3 is always referred to and it is assumed that setae *J*4, *Z*3 and *Z*4 are similar unless otherwise indicated. The important attributes are the size and spacing of the marginal files of cilia on the setae. Cilia are regarded as *even* if each cilium is intermediate or equal in length to the cilia on either side of it, and *uneven* if this is not so. Cilia are *short* if less than diameter of setal mid rib, *medium-lengthed* if × 1-× 1.25 and *long* if more than × 1.25 this diameter. Cilia are *dense* if distance apart is less than diameter of setal mid rib, *medium-spaced* if × 1-× 1.25 and *sparse* if more than × 1.25 this diameter.

The notal sculpturing consists of pits or puncta which are described as *punctations* if circular or oval and *reticulations* if polygonal, the straight edges forming a network. Puncta are *large* if similar or greater in size to setal base *J*3, or *small*. Puncta are *abutting* if the space between them is not greater than × 0.5 each one's diameter, *close* if between × 0.5-× 1 and *well separated* if greater than this diameter.

SYSTEMATICS

Supercohort MACROPYLIDES

Remarks: Balogh (1972: 32) stated in referring to his classification "The . . . Primitive Oribatei or Macropylina is in complete accordance with van der Hammen's system (1959)." This is inaccurate. Van der Hammen (1959) has 7 groups as follows (with Balogh's grouping in parentheses): Palaeacaroidea (= Bifemoratina), Parhypochthonioidea (included in Arthronotina), Enarthronota including Protoplophoridae (Arthronotina and part of Ptyctimina), Mesoplophoroidea (= part of Ptyctimina), Phthiracaroidea (= part of Ptyctimina), Perlohmannioidea (= part of Holonotina) and Nothroidea including Nanhermanniidae and Hermanniidae (= part of Holonotina and part of the Apterogasterina in the Brachypylides or "Higher Oribatids"). Therefore, Balogh's classification differs in 2 important respects from that of van der Hammen: it ignores the rejection of the Ptyctimina as a valid group and changes the point of delineation of the Macropylides from the Brachypylides. Van der Hammen's classification reflects that of Grandjean who established both the Enarthronota (Grandjean 1947a: 215) with the *Protoplophora* included in it, and a classification (Grandjean 1954a: 428-431) which is a detailed precursor of van der Hammen's classification.

It is hard to understand how the Ptyctimina (recognisable by the adult being ptychoid i.e. having an acutely hinged prehysteronotal fissure) has survived as a taxon for so long. Grandjean (1933: 319) pointed out that *Mesoplophora* (ptychoid) has an adult gnathosternum remarkably like that of Hypochthoniidae (non-ptychoid) and should be grouped with that family rather than with the Phthiracaroidea (ptychoid). It appears that the belief that Grandjean's work is based on characters of immature stages which produce a "natural" but difficult classification to follow has inhibited the application of his work. For the Macropylides this had led to an unnecessary stagnation since much of Grandjean's classification is based on adult characters. Not that there is any basis for regarding adult characters as producers of an "artificial" classification. The disadvantage of Balogh's currently accepted classification of the Cryptostigmata seems to be that it was based on descriptions of adults which in many cases included too few characters.

Although the classification by Balogh (1972) is widely used and is included in a recent manual on mites (Krantz 1978) some specialists do follow Grandjean's work. Even then, there may be uncertainty as when Norton (1980), in referring to *Mesoplophora* and other ptychoid mites, states "these and several other *apparently* unrelated oribatid mites" (my italics).

The classification used in this publication follows the trend of Grandjean's (1969) work. The Ptyctimina are not regarded as a valid group. The Protoplophoroidea and Mesoplophoroidea (ex Arthroptyctima) are grouped in 2 different new subcohorts within the Arthronotina. The remaining majority within the disbanded Ptyctimina, the Phthiracaroidea and Euphthiracaroidea (ex Euptyctima), is grouped in the Holonotina which are not considered below.

Cohort ARTHRONOTINA

Diagnosis: Macropylides. Often pale, minute to medium-sized (790 or less) adults. One, 2 or 3 transverse hysteronotal fissures present (Mesoplophoridae appear to lack these fissures, but the presence of only 8 pairs of setae on notal shield indicates that shield's posterior edge represents fissure *TB*3, while posterior and pleural shields inconspicuously merged with ventral shields). External malae either disjunct or conjunct. Mentum undelineated. Femora not divided into 2 separate parts. Immatures similar to adults except sometimes in disposition of hysterosomal shields and always in chaetotaxy and nature of genital shields.

Remarks: The most conspicuous attribute of members of this cohort is the presence of transverse hysteronotal fissures breaking up the rigid integument into a number of separate shields. Just as the form of these fissures varies from a vague line to a hinged break in the soma, so do their functions probably also vary. In the case of *Elliptochthonius profundus* a fissure probably allows bending of the soma in order to negotiate narrow pore spaces in the deeper soil layers, whilst for *Protoplophora palpalis* it allows the back as well as the front of the mite to be folded down to form a protective ball. The advantage of the fissure is not so obvious for mites such as *Hypochthoniella minutissimus* and *Sphaerochthonius splendidus,* but possibly it allows expansion of the hysterosoma to accommodate a large egg.

The attributes of morphological characters in the Arthronotina vary considerably compared with those of the other 2 cohorts of Macropylides. This is the main reason for my establishing 3 new subcohorts within it. One, the Monofissurae, represents a well established taxon in that it includes only the Parhypochthonioidea. On the other hand, the Retrofissurae and Profissurae are entirely new taxa. It may prove preferable to downgrade these 3 subcohorts to superfamilies (Parhypochthonioidea, Mesoplophoroidea, Protoplophoroidea). However, for the time being, the novelty of the grouping, the strangeness of the 2 ex-Ptyctimina superfamily names being applied to much larger and diverse taxa, and my uncertainty as to the importance of the differences between Phyllochthonioidea and the other Retrofissurae, make my classification a reasonable stage in the maturing of the systematics of the cohort.

If the grouping into taxa that I have called the Retrofissurae and Profissurae survives, it will suggest a number of cases of parallel evolution: the folding-up-soma of the Mesoplophoridae and Protoplophoridae; the short, simple somal setae of the Brachychthoniidae and Haplochthoniidae; the long erectile mid-dorsal setae of the Trichthoniidae and Cosmochthoniidae; and the large toadstool-like dorsal setae of the Phyllochthoniidae and Pterochthoniidae.

The Arthronotina exhibit primitive attributes. On the other hand, I regard some attributes as specialised, such as slim setose external malae (e.g. *Heterochthonius gibbus*) and comb-like fixed cheliceral digits (e.g. *Pterochthonius angelus),* which are considered by Grandjean (1947b 1957) as reflections of the setal origins of these structures. Also, although the presence of hysteronotal fissures on all species reflects the primitive nature of the cohort, a greater number of fissures may not be an indication of a more primitive taxon.

The classification of the Arthronotina that I propose to use is outlined below.

A. Subcohort: Monofissurae
- **1. Superfamily:** Parhypochthonioidea
  Families: Parhypochthoniidae
  Gehypochthoniidae
  Elliptochthoniidae

B. Subcohort: Retrofissurae
- **1. Superfamily:** Hypochthonioidea
  Families: Hypochthoniidae
  Eniochthoniidae
  Brachychthoniidae
  Heterochthoniidae
  Trichthoniidae
- **2. Superfamily:** Mesoplophoroidea
  Families: Mesoplophoridae
  Archoplophoridae
- **3. Superfamily:** Phyllochthonioidea
  Families: Phyllochthoniidae
  Atopochthoniidae

C. Subcohort: Profissurae
- **1. Superfamily:** Cosmochthonioidea
  Families: Cosmochthoniidae
  Sphaerochthoniidae
  Pterochthoniidae
  Haplochthoniidae
- **2. Superfamily:** Protoplophoroidea
  Families: Protoplophoridae

KEY TO SUBCOHORTS OF ARTHRONOTINA (ADULTS)

1. Hysteronotal gland present. Only single transverse hysteronotal fissure (*TB*2) present. External malae conjunct. Both pairs of adanal pores (*Jaf, Zaf*) present. Genua of legs with 1 or 2 solenidia. Pretarsi with 3 claws (shorter central claw sometimes rudimentary) ..... Monofissurae

Hysteronotal gland absent. More than 1 transverse hysteronotal fissure (if only 1 is conspicuous it is either *TB*1 or *TB*3). External malae either disjunct or conjunct. Either 1 pair of adanal pores (*Zaf*) present or both pairs absent. Genua may have 0, 1 or 2 solenidia. Pretarsi with 1, 2 or 3 claws (if 3 claws then central 1 most robust) 2

2. Two (rarely only *TB*3) transverse hysteronotal fissures (*TB*2, *TB*3) so that both setae *J*1 and *J*2 on first shield (*NS*1/2) (an exception is Phyllochthonioidea, with toadstool-like dorsal setae, broad areas of striated cuticle on hysteronotum and

narrow first shield not bearing seta *J*2). External malae disjunct. Either 1 pair *(Zaf)* of adanal pores present or both pairs absent. At least genua of legs I and II have 1 or 2 solenidia. Pretarsi with either 1 or 2 subequal claws ..... Retrofissurae

Three (rarely only *TB*1 obvious: *TB*2 obscure, *TB*3 absent) hysteronotal fissures (*TB*1, *TB*2, *TB*3) so that seta *J*1 but not *J*2 on first shield (*NS*1). External malae conjunct. No adanal pores. All genua without solenidia. Pretarsi with 1, 2 or 3 claws but if 2 claws present, 1 usually much slimmer and rarely on pretarsus IV ..... Profissurae

Subcohort MONOFISSURAE n.

Diagnosis: Arthronotina. Single transverse hysteronotal fissure (*TB*2) complete or hinged. Hysteronotal gland with egress pore between setae *Z*4 and *Z*5. Cowl absent or rudimentary, enclosing only part of retracted chelicerae. Cheliceral digits unmodified, dentate. Cheliceral setae both (*ch*1, *ch*2) present and setose. Distal plasmic setae on palp tarsus simple not bifurcate. External malae conjunct. Two pairs of adanal pores *(Jaf, Zaf)* present. On tarsus I, seta *d*1 never simple, at least bifurcate. Genua of all legs with 1 or 2 solenidia. Pretarsi with 3 claws of which shorter central claw may be rudimentary.

Remarks: The Monofissurae is not a new taxon since it includes only the Parhypochthonioidea van der Hammen, 1959, with the following 3 monogeneric families: Parhypochthoniidae, Gehypochthoniidae, Elliptochthoniidae. Although Grandjean (1954a) separated the Parhypochthonioidea from what is here regarded as the rest of the Arthronotina, I prefer to follow Balogh (1972) in placing it in the Arthronotina, especially since the Elliptochthoniidae partly "closes the gap" between the 2 taxa. As 1 gehypochthoniid nymph was collected in the present study, that family is considered in more detail below. The 2 other families are considered briefly as follows. i) Parhypochthoniidae Grandjean, 1932b. Similar to Gehypochthoniidae especially in the general appearance of the gnathosoma. However it is easily distinguished from other Monofissurae by the egress pore of the hysteronotal gland being on an apophysis and by the presence of a setal file *Sa* which includes 4 setae. *Parhypochthonius* does have attributes in common with *Elliptochthonius* that do not occur on *Gehypochthonius*, such as 3 palpocoxal setae, hysteronotal seta *Z4* present and a solenidium on tibia IV, but these are considered at the most to distinguish families. ii) Elliptochthoniidae Norton, 1975. When established it was suggested that this family may in the future have to be grouped in a separate superfamily. Amongst the combination of attributes used in the diagnosis, it should be noted that the hinged transverse hysteronotal fissure (which merges laterally with the ventral fissure immediately behind coxite IV so that the posterior part of the body is movable in relation to the anterior part) occurs on members of the *rhadamanthus*-complex in *Gehypochthonius*. Also used to diagnose the family was the gnathosoma which has a number of substantially modified characters considering that the Monofissurae occupies a primitive position in the classification. The external malae ventrally obscure much of the internal malae and their palpocoxal bases abut onto each other for almost their entire length. There is only one pair of adoral setae. The palp is reduced in that the trochanter and femur are fused and it carries few setae (1-0-2-7). The cowl is extensive, although not completely enclosing the retracted chelicerae. These gnathosomal attributes alone support the suggestion that this family may have to be grouped in a separate superfamily.

Family GEHYPOCHTHONIIDAE Strenzke

Gehypochthoniidae Strenzke, 1963: 251.

Type-genus: *Gehypochthonius* Jacot, 1936.

Remarks: The Gehypochthoniidae currently includes only *Gehypochthonius* so that most further points are made under that generic heading. *Gehypochthonius* and *Parhypochthonius* are closely allied. I would group Gehypochthoniidae under Parhypochthoniidae, but for the presence on *Parhypochthonius* of 4 setae in file *Sa*, which is regarded as important in representing a "preanal segment" (Grandjean 1954a) and is usually absent amongst the Arthronotina (exceptions: Pterochthoniidae and possibly Phyllochthonioidea).

GEHYPOCHTHONIUS Jacot

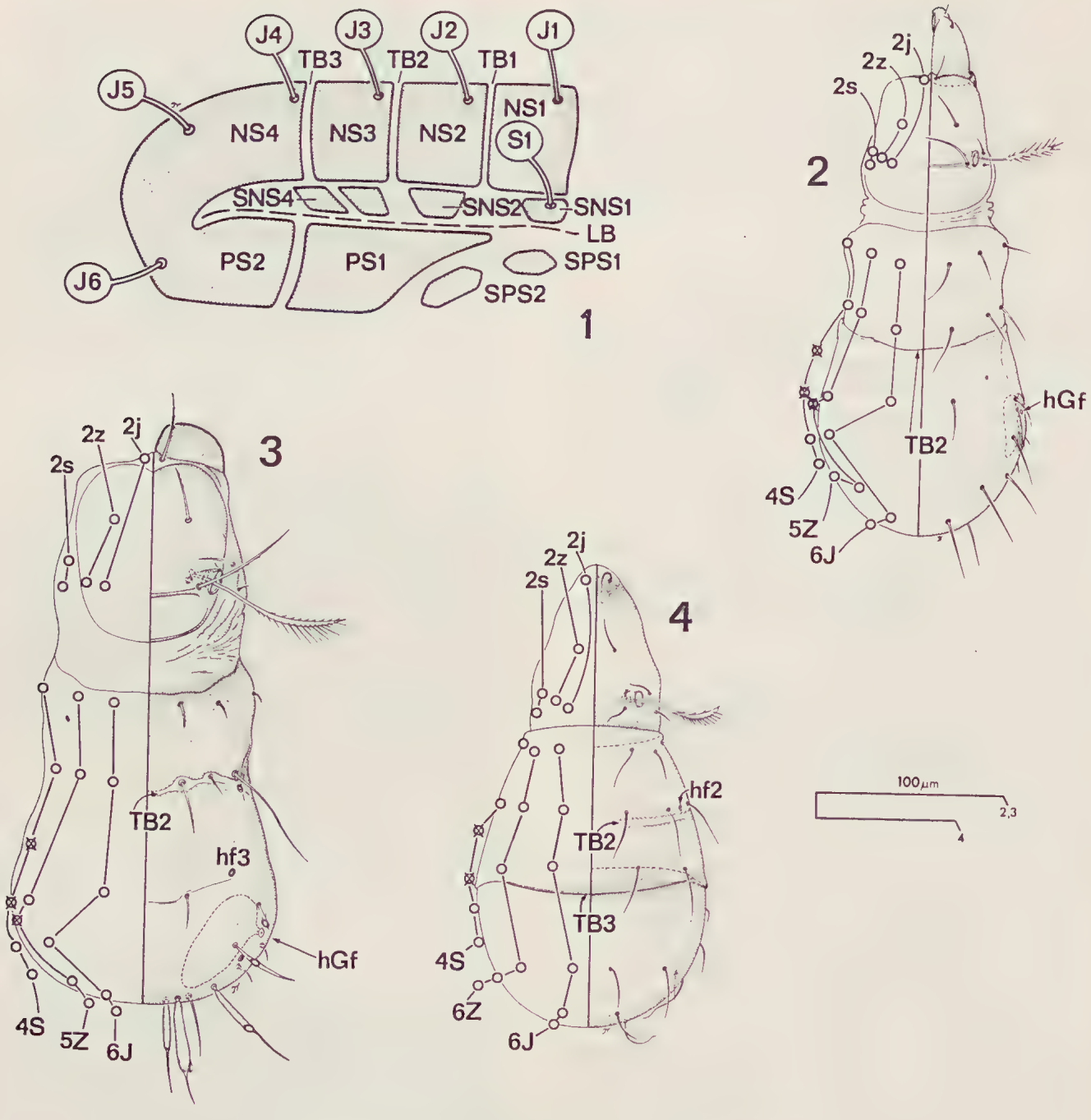
Gehypochthonius Jacot, 1936: 22. Type designation (original): *"Gehypochthonius rhadamanthus* sp.nov."

Type-species: *Gehypochthonius rhadamanthus* Jacot, 1936: 22.

Diagnosis: Monofissurae. Cowl absent. External malae conjunct. Adoral setal file includes 3 pairs, of which *ao*1 is either bifurcate or spreads out distally into a triangulate flap. Palpocoxal setal file includes 2 pairs. Adanal setal file *Sa* absent. Transverse hysteronotal fissure may or may not be hinged and merge with a ventral fissure. Hysteronotal seta *Z*4 absent (present on larva, see Strenzke 1963: fig. 20). No setae in adanal file *Sa*. Palp with 5 free segments and 2 setae on femur. On tarsus I, bifurcate seta *d*1 with 1 branch tapering and 1 expanded into an oval flap. Tibia IV without solenidia.

Morphology: Minute (250-380), pale ivory-white and sometimes partly straw-coloured, chelicerae light brown. Soma bulbous behind seta *J*2 with clear, medium-lengthed refractile setae sticking out like spines. Legs I and IV longer than II and III, I stoutest.

Gnathosoma with conjunct external malae, internal malae not partially obscured ventrally. Leg coxites completely delineated by apodemes, although apodeme separating coxite III from IV sometimes broken.



FIGS. 1-4—Arthronotina: 1, signatures for hysteronotal shields and fissures; 2, *Gehypochthonius rhadamanthus* Jacot, adult, notum; 3, *Gehypochthonius strenzkei* n.sp., tritonymph, notum; 4, *Hypochthoniella minutissimus* Berlese, adult notum.

When transverse hysteronotal fissure hinged, anterior hysteronotum narrower at the fissure and fits into posterior hysteronotum. Similar to structure in *Elliptochthonius*, but not to equivalent fissures of most Arthronotina, where the posterior fits into anterior hysteronotum.

Chaetotaxy. Soma: 2*j*, 2*z*, 2*s*; 6*J*, 5*Z*, 4*S*; 3*ao*, 2*c*, 1*cd*; 3*I*, 1*Id*, 2*II*, 3*III*, 4*IV*; 5 to 8*Jg*, 3*Zg*, 2*Sg*; 2*Ja*, 3*Za*, 0*Sa*. Appendages: *ch*(2), *pa* (0-2-0 or 1-2-11), *I* (1-4 or 6-5-6-22), *II* (1-5-3 or 5-5 or 6-17), *III* (2-2 or 3-2 or 3-3 or 4-13 or 15), *IV* (1 or 2-2-1 or 2-3 or 4-11 or 13). Solenidia: *pa* (0-0-1), *I* (1 or 2-1-3), *II* (1-1-1 or 2), *III* (1-1-0), *IV* (1-0-0).

Hairs generally setose. Adoral seta *ao*1 either bifurcate or spreads out distally into triangulate flap, *ao*2 sometimes stout, blunt rod. Some somal and appendage setae with inconspicuous cilia; plasmic seta *z*2 has conspicuous cilia and take 1 of 2 forms described below under diagnoses of the 2 species-complexes. Posterior hysteronotal setae always tapering distally, but in some cases medially and proximally dilated into a refractile cylinder around a central canal. Some dorsal leg setae (as *G. xarifae*) lanceolate with lateral flaps. Tarsus I, with seta *d*1 short and bifurcate, 1 branch tapering and 1 ovate. If solenidia present on a tarsus or tibia at least 1 is ceratiform or baculiform. Solenidia of genua either piliform (sometimes slightly

blunter than surrounding setae and so approaching ceratiform) or flagelliform.

Distribution: Possibly cosmopolitan—Canada (Nn), Carolina and Florida (Na), France (Pe), Japan (Pc), Maldive Islands (Oc), Australia (Aa).

Remarks: The only species of *Gehypochthonius* described extensively enough to refer to the gnathosoma and appendages is *G. xarifae* Strenzke, 1963. Since the lateral view of the type-species (*G. rhadamanthus* Jacot, 1936: fig. 1) is similar to that of *Elliptochthonius,* I needed to establish whether or not these 2 species were congeneric, because, although the single tritonymph collected during this study is congeneric with *G. xarifae,* it was not certain if either species should be grouped in *Gehypochthonius.* Strenzke (1963: 248) has compared *G. xarifae* and *G. rhadamanthus,* referring to Grandjean's unpublished extensions of the description of *G. rhadamanthus* based on specimens collected in France, but at that time *Elliptochthonius* was not known.

To clarify the situation I examined both described and undescribed mites not collected in the present study. These, together with the material before me, confirm that *G. xarifae* and *rhadamanthus* are similar. However whilst regarding them as congeneric, I place them in separate species-complexes, pending upgrading or abandonment.

***rhadamanthus*-complex**

Diagnosis: Gehypochthonius. Smaller (250-275). Transverse hysteronotal fissure merges with ventral fissure and appears hinged. Plasmic seta *z*2 with short cilia (length × 2 or less of setal diameter). Hysteronotal seta *Z*2 more than × 0.5 length of *S*2. Hysteronotal seta *J*5 less than × 2 length of *J*3 and diameter never more than that of outer rim of alveolus. Setal file *Jg* with 5 or 6 setae. Adoral seta *ao*2 tapered as *ao*3. Appendage chaetotaxy reduced, for example no setae on genu of palp and only 3 setae on both tibiae III and IV. One solenidium on genu I. Solenidium on tibia III longer (at least × 1.1) than the tibia. Solenidium on genu IV about twice (× 1.9-2.1) length of the genu.

Remarks: As only 1 species is included, further information is under the species heading. As noted there, the species may be composite.

***Gehypochthonius rhadamanthus* Jacot**

(Fig. 2)

Gehypochthonius rhadamanthus Jacot, 1936: 22.
Gehypochthonius rhadamanthus Jacot: Aoki, 1975: 55.

Adult

Idiosomal length 250-275 (Carolina—255, N.S.W.—250, Japan—262-275). Main cheliceral axis apparently at less than 45° angle from horizontal somal axis even in unsquashed specimens. Apodeme separating coxite III from IV broken. Specimen from Japan atypical (as original description) in that seta *Z*2 longest in second rank. Seta *J*5 slimmest on Carolina specimens and stoutest (equal in diameter to its alveolus) on N.S.W. specimens. Specimen (Fig. 2) from Carolina differs compared with those from other localities in that setae *J*6 and *Z*6 displaced forward.

Chaetotaxy of soma varies in that file *Jg* has 6 setae on Carolina and Japanese specimens and 5 setae on N.S.W. specimens. Chaetotaxy of appendages (N.S.W. adults, and same on femora, genua and tibiae of Carolina adults): *pa* (0-2-2-11), *I* (1-4-5-6-22), *II* (1-5-3-5-17), *III* (2-2-2-3-13), *IV* (1-2-1-3-11).

Material examined: Twenty-five syntypes ("cotypes", 34F23.2-5, Smithsonian Institution, U.S.A.) from Carolina on single slide. One adult (Ac8636, National Science Museum, Tokyo, Japan) from Japan. Three adults (N19794-N19796), litter and soil, open *Eucalyptus* forest, Cordeaux (34° 08'S, 150° 43'E), New South Wales, Australia, 9.6.1978, T. Moulton.

Specimens from N.S.W. well cleared but squashed, and characters of gnathosoma and appendages (some presented under genus heading) clearly discernible. Syntypes in good condition yet poorly cleared and sometimes shrivelled. Most characters of gnathosoma and appendages discernible, but chaetotaxy of appendages only confirmed on femur, genu and tibia, and for solenidia alone on tarsi. Specimen from Japan poorly cleared and shrivelled. Many characters of gnathosoma and appendage chaetotaxy not discernible, but attributes of transverse hysteronotal fissure, seta *Z*2 and solenidia on tibia III and genu IV justify its inclusion in this species-complex.

Distribution: Widespread—Carolina (Na), France (Pe), Japan (Pc), Australia (Aa). The majority of specimens examined by Jacot (1936) were from 5-12.5 cms deep in the soil. Records of other specimens are from soil or plant litter under shrubs or trees.

Remarks: G. rhadamanthus, with a hinged transverse hysteronotal fissure and simpler setae, appears adapted to live in deeper soil layers than its congeners and therefore superficially resembles *Elliptochthonius* species. If the morphological variations of this widespread species later prove to reflect distinct species, and the above diagnosis for the *rhadamanthus*-complex remains valid, I would recommend that the genus be limited to this complex alone.

***xarifae*-complex**

Diagnosis: Gehypochthonius. Bigger (290-380). Transverse hysteronotal fissure not merging with a ventral fissure and not hinged. Plasmic seta *z*2 with long cilia (length of longest × 5 or more of setal

diameter). Hysteronotal seta *Z*2 less than × 0.5 length of *S*2. Hysteronotal seta *J*5 either more than × 2 length of *J*3 or its diameter in parts greater than that of outer rim of its alveolus, or both attributes present. Setal file *Jg* with 7 or 8 setae. Adoral seta *ao*2 blunt, spindle-shaped or parallel-sided rod. Appendage chaetotaxy not so reduced, for example 1 seta on palp genu and 4 setae on both tibiae III and IV. Two solenidia on genu I. Solenidium on tibia III shorter (at most × 0.9) than tibia. Solenidium on genu IV conspicuously shorter than twice (× 1.5 or less) length of genu.

Material examined: Specimens of new species below. Holotype of *G. frondifer* from Japan (Ac8567, National Science Museum, Tokyo, Japan); notum uppermost, slightly shrivelled, only partially cleared and including 2 substantial opaque food boli, some attributes difficult to discern.

Distribution: Widespread—Florida (Na), Maldive Islands (Oc), Australia (Aa). From moss or plant litter under shrubs or trees.

Remarks: Although little is known about *Parhypochthonius urticinus* Berlese 1910a: 219 and fig. 43, the dorsum of the female illustrated with egg is so similar to that of members of this complex that it is here included in *Gehypochthonius*.

Four species are included in the *xarifae*-complex: *G. frondifer* Aoki, 1975; *G. strenzkei* **n.sp.**, *G. urticinus* (Berlese, 1910a) **n.comb.**, *G. xarifae* Strenzke, 1963.

Gehypochthonius strenzkei n.sp.

(Fig. 3)

Tritonymph

Idiosomal length 290 (1); appendage lengths—*ch* 27.5, *pa* 55, *I* 125, *II* 95, *III* 95, *IV* 120; femur breadths—*pa* 12.5, *I* 25, *II* 15, *III* 15, *IV* 15. Transverse hysteronotal fissure (*TB*2) indistinct, bearing setae *J*2 and *Z*2, (fissure *TB*2 of adults set behind these setae). Indistinct disc around the hysteronotal gland pore (*hGf*) not illustrated. No indication of vestigial presence of seta *Z*4. Five hysteronotal setae (*J*4, *J*5, *J*6, *Z*3, *Z*5) have swollen, refractile zone, but not setose seta *Z*6. Four of these 5 setae (all but *J*6), on right side only, bear a ring-like refractile structure, only present on seta *J*5 on left side. Opisthosternal chaetotaxy: 5*Jg*, 3*Zg*, 2*Sg*, 2*Ja*, 3*Za*, 0*Sa*. Gnathosoma similar to that of adult *G. xarifae* except adoral seta *ao*1 bifurcate with 2 tapering branches that lack joining hyaline flap. Appendage chaetotaxy and solenidiotaxy includes 6 setae on femur I and 4 setae on genu II but otherwise matches that of tritonymph of *G. xarifae*. On genu IV, dorsal seta simple and short (× 0.5 length of genu).

Adult

Idiosomal length about 350 (2—very squashed). Similar to tritonymph except adult attributes as in *G. xarifae*. There are further differences. Plasmic seta *z*2 with 11 cilia in long-cilia file as adult *G. xarifae*, but not its own tritonymph and *G. frondifer* which have 14 or 15 such cilia. Some posterior hysteronotal setae swollen and refractile as tritonymph, but lack ring-like structures and have relatively longer slim, tapering tips on some setae (*J*5, *J*6, *Z*5). Appendage chaetotaxy and solenidiotaxy as adult *G. xarifae* except only 1 seta on trochanter IV as tritonymph of *G. strenzke* and *xarifae*. Differs from its own tritonymph in having 5 setae on genu II. Dorsal setae on legs tend to be short and simple compared with long lanceolate equivalent setae on adults of *G. xarifae*, for example, on genu IV where solenidium about × 1.2 length of genu, associated seta about × 0.5 length of genu (on *G. xarifae* solenidium about equal to length of genu, associated seta about × 1.6 length of genu with hyaline flap so that lanceolate).

Material examined: Holotype tritonymph (N19797), litter and sparse grass, under *Acacia sophorae*, Piccaninnie Ponds, 3.7.1974, D. C. Lee. Two females (N19798 and N19799), litter and soil, open *Eucalyptus* forest, Cordeaux (34° 08′S, 150° 43′E), New South Wales, Australia, 9.6.1978, T. Moulton.

Distribution: Australia (Aa). New South Wales: sclerophyll forest, Great Dividing Range. South Australia: Piccaninnie Ponds, coastal closed-scrubland, 1TN (-/8).

Remarks: G. strenzkei is based on 1 tritonymph collected as part of this study, supported by what are regarded as conspecific adults from N.S.W. Certain characters, such as the number of cilia on plasmic seta *z*2, suggest that the adults may belong to a separate closely allied species. But the ring-like refractile structures, which are not bilaterally symmetrical in their distribution amongst some hysteronotal setae of the tritonymph, are regarded as a non-inherited attribute.

The shape of the posterior hysteronotal setae clearly distinguishes *G. strenzkei* from *urticinus* and *xarifae* on which such setae are much longer and slimmer. Because *G. xarifae* is fully described, differences in leg chaetotaxy and shape of hairs on leg IV have been referred to above, but this is not possible for *G. urticinus*. The hysteronotal setae are much more similar to those of *G. frondifer*, for which I was unable to establish the leg chaetotaxy or shape of hairs on leg IV. The main attribute I use to distinguish this species from *G. frondifer*, is the setose hysteronotal seta *Z*6. On *G. frondifer* seta *Z*6,

although smaller, is distinctly swollen like *J*6. Furthermore, although not conspicuous, the swollen hysteronotal setae such as *J*5 on *G. frondifer* are more curved in outline with a shorter tapered tip.

Subcohort RETROFISSURAE n.

Diagnosis: Arthronotina. Usually 2 transverse hysteronotal fissures *(TB*2, *TB*3), sometimes obscure as when hysteronotal setae so far towards anterior that seta *J*4 set well within anterior half of hysteronotum (Heterochthoniidae) or when notal setae broadly lanceolate, spatulate or umbellate and extent of notal shields considerably reduced (Phyllochthonioidea), or only 1 fissure *(TB*3) present when prehysteronotal fissure acutely hinged (Mesoplophoroidea). No hysteronotal gland with egress pore between setae *Z*4 and *Z*5. Cowl present, enclosing retracted chelicerae. Cheliceral digits usually unmodified, sometimes edentate. Cheliceral setae both usually present and setose, sometimes *ch*1 absent, rarely *ch*2 enlarged, lanceolate. One distal plasmic seta on palp tarsus usually bifurcate, no such seta longer than tarsus. External malae disjunct. Either 1 pair *(Zaf)* of adanal pores present or both pairs absent. On tarsus I, seta *d*1 simple or bifurcate. At least genua I and II with 1 or 2 solenidia. Pretarsi with either 1 claw or 2 subequal claws.

Remarks: The Retrofissurae is a new taxon. It is very diverse in form and, as pointed out above in the remarks on the cohort, the variations reflect similar variations in the Profissurae suggesting the parallel evolution of the 2 groups. The name Retrofissurae is intended to indicate a main attribute that contrasts with the Profissurae, i.e. that the transverse hysteronotal fissures are usually more posterior, fissure *TB*1 not being represented. The most heavily weighted attribute in this study is the presence of disjunct external malae, a possibly primitive condition also found in the Bifemoratina, but not elsewhere amongst the Cryptostigmata. On the other hand, certain species (see *Trichthonius pulcherrimus* below) have a conspicuously modified gnathosoma. The presence of solenidia on leg genua is an attribute common amongst Cryptostigmata, contrasting with their absence on members of the Profissurae. Attributes of the adult claws also appear to be a reliable diagnostic feature although there are exceptions and they diagnose lower taxa amongst some other groups of Cryptostigmata. The correlation of the attributes of these 4 characters, with few exceptions, is considered here as a good case for a new splitting of a large part of the Arthronotina into the Retrofissurae and Profissurae.

The Retrofissurae includes 3 superfamilies: Hypochthonioidea Balogh, 1961; Mesoplophoroidea van der Hammen, 1959; Phyllochthonioidea Travé, 1967. The Hypochthonioidea include most members of this subcohort, and since some were collected in this study, they are considered further below. The Mesoplophoroidea, which only include 2 genera and about 7 species, were considered briefly by myself (Lee 1981) under the now disbanded Arthroptyctima. The Phyllochthonioidea are considered below in these remarks, although none were collected in this study.

The superfamily Phyllochthonioidea Travé, 1967: 103 is a group of minute (length 200-340) pale mites with large dilated umbellate dorsal setae. *Atopochthonius artiodactylus* Grandjean, 1948 was described as the type and only species of Atopochthoniidae with a Holarctic distribution across southern Canada (Nn), Mediterranean region (Pm) and forest zones of Western Europe (Pe), as far as the Altai Mountains in Mongolia (Ps). A second species *(Phyllochthonius aoutii* Travé, 1967) from the Ivory Coast (Ew) was established as the type of Phyllochthoniidae. This family has since been recorded from broad-leaved forests in southern Eurasia (Ps) and the far east of the U.S.S.R. (Ps). The 2 genera are similar in appearance although their chaetotaxy differs. For example, *A. artiodactylus* has a gnathosoma very similar to that of *P. aoutii,* but lacks 2 setal pairs *(ao*1, c1*p)*. The hysterosomal chaetotaxy is confused because Grandjean (1948) regards seta *J*2 as absent so that the large erectile seta (third in file *J*) is labelled *"f1"*, whilst Travé (1967) labels it *"e1"*. There are more hysterosomal setae on *P. aoutii* and, if Grandjean (1948) is correct in considering the second hysteronotal rank to be absent, then setal file *Sa* is present on this species. It may prove preferable to group these 2 genera in 1 family, but for the time being I have retained both families because the presence or absence of setal file *Sa* has in the past been given considerable weight on the basis that it reflects the presence or absence of a "preanal segment" (see above remarks on Gehypochthoniidae).

The Phyllochthonioidea are unusual in their attributes of 2 of the 4 characters which are weighted in the diagnosis of Retrofissurae and this makes its grouping with the other 2 superfamilies questionable. The 2 attributes are that there is a fissure *(?TB*1*)* close behind seta *J*1 and the pretarsus has 2 claws rather than 1 claw. But it should be noted that the hysteronotal shields are considerably reduced and that the 2 claws are stout and symmetrical, whilst, when 2 claws are present on Profissurae species, they (one known exception) are assymmetrical with 1 hyaline and slim as for the lateral claws of allied species and the other refractile and stout as for the central claw (rarely the 2 claws are more similar in girth, in which case the slimmer claw is ciliate).

Superfamily HYPOCHTHONIOIDEA

Diagnosis: Retrofissurae. Prehysteronotal fissure not acutely hinged. Two narrow transverse fissures *(TB*2,

*TB*3) dividing hysteronotal shield into 3 parts. Dorsolateral longitudinal fissure *(LB)* anterior to seta *J5* delineates dorsal margin of pleural shield, ventrally separate from aggenital and adanal shields. Notal setae rarely broadly umbellate with *J*3 extending beyond posterior edge of soma, if so then ciliate. Pretarsus with 1 claw.

Remarks: The Hypochthonioidea as used here is a more extensive superfamily than as delineated by Balogh (1972) and includes 5 families: Hypochthoniidae Berlese, 1910a; Eniochthoniidae Grandjean, 1947a; Brachychthoniidae Thor, 1934; Heterochthoniidae Grandjean, 1954a; Trichthoniidae **n.f.** The Hypochthoniidae and Heterochthoniidae were not represented in collections for this study and are not further considered.

Family ENIOCHTHONIIDAE Grandjean

Eniochthoniinae Grandjean, 1947a: 223.

Type-genus: *Hypochthoniella* Berlese, 1910a.

Remarks: The Eniochthoniidae currently include only *Hypochthoniella* so that most further points are made under that generic heading. The family is closely allied to the Hypochthoniidae. These 2 families are usually regarded as the only members of the Hypochthonioidea.

HYPOCHTHONIELLA Berlese

Hypochthoniella Berlese, 1910a: 218. Type designation (original): *"H. (Hypochthoniella) pallidulus* K.", misidentification of *Hypochthonius minutissimus* Berlese, 1903 subsequently indicated as type (van der Hammen 1959: 17).

Arthrochthonius Ewing, 1917: 130. Type designation (original): *"Hypochthonius pallidulus* Koch", misidentification as type designation for *Hypochthoniella.*

Eniochthonius Grandjean, 1933: 32. Type designation (original): *"Eniochthonius pallidulus* (Mich.)", *Hypochthonius pallidulus* Koch: Michael, 1888: 537 syn. with *Hypochthonius minutissimus* Berlese, 1903 (see van der Hammen 1959: 17).

Type-species: *Hypochthoniella minutissima* (Berlese, 1903: 252).

Diagnosis: Hypochthonioidea. Minute (280-385), pale mites. Anterior of 2 transverse hysteronotal fissures (*TB*2) relict, not continuous across mid-notal line and conspicuously closer to seta *J*2, than seta *J*3, posterior fissure (*TB*3) about halfway between seta *J*1 and *J*6. Anterior part of pleural shield (*PS*1) not separated off by vertical fissure level with transverse hysteronotal fissure *TB*3. Hysteronotal setae *J*3 and *Z*3 subequal in length to setae *J*2 and *Z*2, setose and never longer than distance between setal bases *J*1 and *J*3. Hysteronotal seta *S*2 not as near to mid-notal line as *Z*1. Pair of merged coxites III and IV also merge with each other across mid-sternal line. No proteronotal eye or eyes in zone between setae *j*1 and *z*1. On tarsus I, bifurcate seta *d*1 with 1 branch tapering and 1 expanded into small disc. Adoral file includes 3 setae of which *ao*2 has distal teeth.

Material examined: Other than the specimens of *H. minutissima,* 1 syntype of *H. borealis* ("cotype", 37F1w-4, Smithsonian Institution, U.S.A.) from New Hampshire on a slide. This specimen slightly curled up, dorsal surface uppermost, well cleared and despite granular integument most attributes of dorsal and ventral surfaces distinguishable except on gnathosoma. Probably female since positor has long distal setae.

Distribution: Widespread in temperate regions (Nn, Na; NTc; Em; Pe, Pm, Ps, Pc; Os; Aa, An) with some indication that its members commoner in fermantation or deeper soil layers, where there is a substantial leaf-litter layer as in forests, woodland or scrubland.

Remarks: The most data on *Hypochthoniella* is to be gleaned from Grandjean's work (see below) on the type-species. The brief description of *H. borealis* clearly distinguishes it from the type-species, stating that it is larger (about 385) and has a notal plasmic seta *z*2 with only 4 or 5 short cilia (their length is about half that of the broadest width of the seta). I was uncertain as to whether or not *H. borealis* was grouped in the correct genus, but the disposition of somal shields is very much as on *H. minutissima* and both species have a large pore posterior to the acetabulum for leg IV.

Two species are included in *Hypochthoniella: H. minutissima* (Berlese, 1903); *H. borealis* (Jacot, 1939).

Hypochthoniella minutissima (Berlese)

(Fig. 4)

Hypochthonius pallidulus Koch: Michael, 1888: 537.

Hypochthonius minutissimus Berlese, 1903: 252.

Hypochthonius (Hypochthoniella) pallidulus Koch: Berlese, 1910a: 218

Eniochthonius pallidulus: Michael not Koch: Grandjean, 1933: 32.

Eniochthonius grandjeani van der Hammen, 1952: 13.

Female

Dull ochre, becoming orange at shield edges. Integument appears granular even in well cleared specimens. Refractile parts (external malae, cheliceral extremities, setae and claws) at least as pale as general integument. Idiosomal length 315 (25 ex Piccaninnie Ponds, 280-360); appendage lengths (for 320 not containing an egg)—*ch* 20, *pa* 50, *I* 115, *II* 110, *III* 95, *IV* 115; femur breadths—*pa* 10, *I* 17.5, *II* 17.5, *II* 17.5, *III* 15, *IV* 15. Prehysteronotal fissure appears

hinged and expandable so that, in relation to hysterosoma, propodosoma can move up and down through about 10°, and backwards and forwards over about 20μm. Anterior transverse hysteronotal fissure (*TB*2) relict, appearing to be shallow furrow on inner surface of integument. Posterior transverse hysteronotal fissure (*TB*3) hinged. In specimen illustrated (Fig. 4), posterior edge of anterior shield consists of both dorsal complete line and ventral broken line level with seta *J*3, whilst anterior edge of the posterior shield (which can be in forward position, level with seta *J*3) in backward position level with dorsal posterior edge of anterior shield. Specimens contain up to 3 food boli, anterior 1 usually diffuse, including what appears to be fungal hyphae and spores. All positors observed have stout long distal setae as on females with eggs, so all adults regarded as female. Amongst 25 registered females examined in detail, 15 without eggs, whilst 10 contain single large (length about 130) ellipsoidal egg. Average length of females with eggs 10 greater than those without.

Material examined: Twenty-five females (N1979150-N1979174), litter and sparse grass, under *Acacia sophorae,* Piccaninnie Ponds, 3.7.1974 and 20.8.1975, D. C. Lee. One female (N1979175), litter and sparse moss, under *Eucalyptus incrassata,* Ferries-McDonald, 20.6.1974, D. C. Lee. One female (N1979176), litter and sparse moss, under *Eucalyptus obliqua,* Mt Lofty, 9.5.1974, D. C. Lee.

Distribution: Widespread, as for genus. South Australia: Ferrries-McDonald, mallee-broombush open-scrubland, 1 (1/8); Piccaninnie Ponds, coastal closed-scrubland, 60 (6/8); Mt Lofty, sclerophyll open-forest, 1 (1/8).

Remarks: Confusion over the nomenclature relating to this species and its genus results from *Hypochthonius pallidulus* Koch, 1836: 3 (20) being the nymph of *H. rufulus* Koch, 1836: 3 (19) (syn. Grandjean 1933: 32), whilst *H. pallidulus* Koch: Michael, 1888: 537 is *Hypochthoniella minutissima.*

The most informative descriptions of *H. minutissima* (as *Eniochthonius pallidulus)* are by Grandjean: development of ventral region of soma (Grandjean 1933) development of lateral region of soma (Grandjean 1934): structure of seta *d*1 on tarsus I (Grandjean 1941); setation of genua (Grandjean 1942); gnathosoma (Grandjean 1957); solenidiotaxy (Grandjean 1964). The external morphology of this species, and so this family, is still incomplete in that for example, the leg chaetotaxy is not fully described.

Family BRACHYCHTHONIIDAE Thor

Brachychthoniidae Thor, 1934: 115.

Type-genus: *Brachychthonius* Berlese, 1910a.

Diagnosis: Hypochthonioidea. Minute (130-270), pale mites. Two complete transverse hysteronotal fissures (*TB*2, *TB*3), anterior fissure (*TB*2) never conspicuously closer to seta *J*2 than to *J*3, posterior fissure (*TB*3) about halfway between seta *J*1 and *J*6 or posterior to that position. Anterior part of pleural shield (*PS*1) separated off by vertical fissure level with transverse hysteronotal fissure *TB*3. Hysteronotal setae *J*3 and *Z*3, not more than × 1.5 length of setae *J*2 or *Z*2, setose, ciliate or lanceolate and never longer than distance between setal bases *J*1 and *J*3. Hysteronotal seta *S*2 as near to mid-notal line as *Z*1 or nearer. Pair of merged coxites III and IV do not merged with each other across mid-sternal line. No proternotal eye or eyes in zone between setae *j*1 and *z*1. On tarsus I, seta *d*1 simple. Adoral file usually includes 1 seta (*ao*2), reduced seta *ao*3 rarely present (*Neobrachychthonius*).

Material examined: Other than species collected during present study, brachychthoniid mites previously recorded from South Australia (Womersley 1945) also considered. Two species represented in both collections, 2 in Womersley's work alone and 3 in just this study, making 7 species altogether.

Distribution: Widespread, probably cosmopolitan (Niedbala 1972b 1977, Chinone 1978) and in wide variety of habitats especially moss, plant litter, and soil.

Remarks: The Brachychthoniidae are by far the largest family in the Arthronotina whilst exhibiting relatively little morphological diversity. Balogh (1972) included 5 genera. I follow a classification of European brachychthoniids (Moritz 1976a, 1976b) including 10 genera which, although it may be excessively divided, works well in classifying the material before me. One problem in classifying brachychthoniids is that the descriptions of many included species are too brief. For example, the leg chaetotaxy is known for very few species, as tabulated with the redescription of *Brachychochthonius lydiae* by Reeves and Marshall (1971), which refers to all of the more complete descriptions of brachychthoniids.

Niedbala (1972a, 1973) recognised 7 genera amongst which he attempted to establish phylogenetic relationships. *Eobrachychthonius* was regarded as the most primitive because of its 4 subnotal shields, whilst other genera were more or less advanced depending on the degree of either loss or fusion of these shields with the notal shield or each other. Furthermore, the family was regarded as having evolved along 2 branches: *Poecilochthonius* and *Synchthonius* constituting a minor branch in which a furrow indicates the line of merging of 2 subnotal shields (*SNS*2 and *SNS*3). The similarities of *Poecilochthonius* to *Brachychochthonius* and of *Synchthonius* to *Liochthonius* were regarded as "convergent similarity" and not due to "ways of evolution".

I have found it useful to newly group the 10 genera of Brachychthoniidae in 3 genus-complexes as follows:

1) *Brachychthonius*-complex— *Brachychochthochnius* Jacot, 1938; *Brachychthonius* Berlese, 1910a; *Eobrachychthonius* Jacot, 1936; *Poecilochthonius* Balogh, 1943.

2) *Liochthonius*-complex—*Liochthonius* van der Hammen, 1959; *Mixochthonius* Niedbala, 1972a; *Synchthonius* van der Hammen, 1952; *Verachthonius* Mortitz, 1976a.

3) *Neobrachychthonius*-complex— *Neobrachychthonius* Moritz, 1976b; *Neoliochthonius* **n. name** (for *Paraliochthonius* Moritz, 1976a).

The genera are considered below only if their representatives have been collected in South Australia, on the other hand all the genus-complexes are considered. The 2 characters heavily weighted in diagnosing the genus-complexes are the presence or absence of a fissure separating off the anterior subnotal shield (*SNS*1) and the position of hysteronotal seta *Z*2. Normally the position of the anterior 2 ranks of hysteronotal setae of Arthronotina is that the 3 files are well spaced and sub-parallel, but in the Brachychthoniidae, seta *S*2 is always displaced towards mid-notal line, whilst *Z*2 is sometimes similarly displaced.

Key to Genera of Brachychthoniidae

1. Hysteronotal seta *Z*2 displaced towards mid-notal line, base at least × 2 its own diameter away from line joining setae *S*2 and *Z*3. Anterior subnotal shield (*SNS*1) may or may not be separate from hysteronotal shield 2

   Hysteronotal seta *Z*2 not displaced towards mid-notal line, base on or close to line joining setae *S*2 and *Z*3. Anterior subnotal shield (*SNS*1) separate from hysteronotal shield. *Brachychthonius*-complex 3

2. Anterior subnotal shield (*SNS*1) separate from hysteronotal shield. *Neobrachychthonius*-complex 6

   Anterior subnotal shield (*SNS*1) merged with hysteronotal shield. *Liochthonius*-complex 7

3. Longitudinal furrow delineates, without separating off, marginal parts of hysteronotal shield bearing setae *Z*1, *S*2, *Z*2, *Z*3, *Z*4. Four separate subnotal shields present. Adanal seta *Za*2 conspicuously stouter than *Za*1 and *Za*3. Pair of merged coxites III and IV also merge with each other across mid-sternal line ..... *Eobrachychthonius*

   No such longitudinal fissure on hysteronotal shield as above. Two or 3 separate subnotal shields present. Adanal setae *Za*1 and *Za*2 similar, either both slim like *Za*3 or both stout. Pair of merged coxites III and IV separated by fissure along mid-sternal line 4

4. Adanal setae in file *Za* similarly slim, although *Za*2 may be slightly longer than other 2 setae ..... *Brachychthonius*

   Anterior 2 adanal setae in file *Za* conspicuously longer and/or stouter than *Za*3 5

5. Three subnotal shields (*SNS*4 present). Adanal seta *Ja*1 on striated cuticle or narrow oval shield *Brachychochthonius*

   Two subnotal shields (*SNS*4 absent). Adanal seta *Ja*1 on broadly triangulate shield ..... *Poecilochthonius*

6. Two palpocoxal setae (*c*1*p* absent). Adoral seta *ao*2 tapers to distal end. Proteronotal plasmic seta *z*2 broadens distally into a subspherical ciliate ball. Subnotal shield *SNS*3 merges with hysteronotal shield ..... *Neoliochthonius*

   Three palpocoxal setae (*c*1*p* present). Adoral seta *ao*2 stout and distally dilated. Seta z2 broadens distally into oval ciliate ball with longitudinal axis at least × 2 greatest transverse axis. Subnotal shield *SNS*3 separate from hysteronotal shield ..... *Neobrachychthonius*

7. Subnotal shield *SNS*3 merges with hysteronotal shield or absent. Posterior setae in hysteronotal file *J* spaced normally, *J*6 nearly level with *Z*6 in relation to posterior margin of hysteronotal shield. Adoral seta *ao*2 slim and tapering *Liochthonius*

   Subnotal shield *SNS*3 separate from hysteronotal shield. Posterior setae in hysteronotal file *J* almost as *Liochthonius* or compacted forward, *J*6 level with point midway between *Z*5 and *Z*6 in relation to posterior margin of hysteronotal shield. Adoral seta *ao*2 lanceolate or parallel sided with blunt distal end 8

8. Hysteronotal setae conspicuously ciliate. Seta *J*6 more nearly level with seta *Z*6 in relation to posterior margin of hysteronotal shield than to point midway between *Z*5 and *Z*6. Adoral seta *ao*2 broadly lanceolate ..... *Mixochthonius*

   Hysteronotal setae never conspicuously ciliate. Seta *J*6 nearly level to point midway between *Z*5 and *Z*6 in relation to posterior margin of hysteronotal shield. Adoral seta *ao*2 parallel sided with blunt distal end 9

9. Adanal seta *Za*2 conspicuously longer and stouter than *Za*1 and *Za*3. Three setae in aggenital setal file *Jg* (*Jg*4 absent). Two setae on both genu III and IV ..... *Synchthonius*

   Adanal seta *Za*2 and *Za*1 similar, either both slim or both stout, although *Za*2 may be slightly longer. Four setae in aggenital setal file *Jg* (*Jg*4 present). Three setae on both genu III and IV ..... *Verachthonius*

BRACHYCHTHONIUS-complex

Diagnosis: Brachychthoniidae. Anterior subnotal shield (*SNS*1), bearing seta *S*1, separate from hysteronotal shield. Hysteronotal setae *Z*1, *S*2, *Z*2 and*Z*3 in nearly straight line parallel to lateral margin of notal shield because seta *Z*2 not displaced towards mid-notal line. Subnotal shield *SNS*3 separate from hysteronotal shield. Adoral seta *ao*2 parallel-sided with blunt distal end. Three setae on both genu III and IV (1 ventral seta present). Coxite IV bearing 4 setae.

Remarks: The *Brachychthonius*-complex is made up of 2 groups: *Eobrachychthonius* and the other 3 genera. *Eobrachychthonius* is not closely allied to the other genera, but it is useful to group them together because of the similar position of hysterononal seta *Z*2, 1 of the most important characters referred to in the briefer descriptions. *Eobrachychthonius* is hardly sculptured at all on its notum, but its hysteronotal shields have a marginal strip delineated by a furrow. The other 3 genera usually have strongly sculptured hysteronotal shields with a marginal ridge. Possibly these 2 types of marginal zonation are reflected in the similar lack of displacement of seta *Z*2 towards the mid-notal line so that it remains on the margin. The marginal ridges also appear in this genus-complex to be correlated with the position of the posterior setae in file *J*, since they often end posteriorly in a

pair of tubercles bearing setae *J*6, which in turn are usually more anteriorad, file *J* being compacted forward.

Eobrachychthonius montanus Hammer, 1952 does not fit into that genus nor the rest of this genus-complex, but is tentatively newly combined below with *Verachthonius*.

Four genera are included in the *Brachychthonius*-complex: *Brachychthonius* Berlese, 1910a; *Brachychochthonius* Jacot, 1938; *Eobrachychthonius* Jacot, 1936; *Poecilochthonius* Balogh, 1943. Only *Brachychochthonius* and *Poecilochthonius* have been collected in South Australia and are considered below.

BRACHYCHOCHTHONIUS Jacot

Brachychochthonius Jacot, 1938: 130. Type designation (original): "*Brachychochthonius jugatus* sp.nov.".

Sellnickochthonius Krivolutsky, 1964: 935. Type designation (original): "*Brachychthonius zelawaiensis* Sellnick".

Brachychthonius Berlese: Chinone and Aoki, 1972: 223 (in part). Type indication: "*Brachychthonius berlesei* Willmann, 1928", correct identification of "*B. brevis* (Mich)": Berlese 1910a (see van der Hammen 1959: 19).

Type-species: *Brachychochthonius jugatus* Jacot, 1938: 130.

Diagnosis: *Brachychthonius*-complex. Hystero notal shields without marginal longitudinal furrows, so that shield bearing setae *Z*1, *S*2, *Z*2, *Z*3 and *Z*4 not delineated from more central part. Three subnotal shields (*SNS*1, *SNS*3, *SNS*4) separate from hysteronotal shields. Pair of merged coxites III and IV separated by fissure along mid-sternal line. Adanal seta *Ja*1 on striated cuticle or narrow oval shield. Anterior 2 adanal setae in file *Za* conspicously longer and/or stouter than *Za*3. Posterior setae in hysteronotal file *J* compacted forward so that *J*6 level with seta *Z*5 in relation to posterior margin of hysteronotal shield.

Distribution: Widespread, probably cosmopolitan.

Remarks: *Brachychochthonius* species separate out best under *Sellnickochthonius* in the keys of Balogh (1972). It is difficult to establish how many nominal species should be included in this genus because a number of possible members are known only by characters of their notal surface, which is insufficient to distinguish them from *Brachychthonius* and *Poecilochthonius*. Also, in the comprehensive list by Niedbala (1972), species of these 3 genera are all grouped in *Brachychthonius*. When Moritz (1976b) established the concept off this taxon as used here, he included 12 species from Europe and later Chinone (1978) included a further 5 species from Japan also *Brachychochthonius lydiae* Jacot from North America is returned to this genus. Therefore, with at least 18 species, it may be the largest genus in the *Brachychthonius*-complex. Two species (*B. elsosneadensis* and *B. cricoides*) in *Brachychochthonius* have been collected in South Australia and are considered below.

Brachychochthonius elsosneadensis (Hammer)

(Fig. none)

Brachychthonius elsosneadensis Hammer, 20.

Brachychthonius elsosneadensis Hammer: Chinone and Aoki, 1972: 229.

Female

Shields either dull orange or almost straw-coloured or pale ivory white. Darker orange specimens sometimes with adhesive, dirty exudate conspicuous at posterior end of soma. Idiosomal length 165 (25 ex Piccaninnie Ponds, 142.5-177.5); appendage lengths (for 165 not containing egg)—*ch* 5, *pa* 20, *I* 47.5, *II* 40, *III* 45, *IV* 57.5; femur breadths—*pa* 5, *I* 14, *II* 11, *III* 11, *IV* 13. Adults from Mt. Lofty and Knott Hill with idiosomal length within 162.5-182.5. All positors observed appeared similar to those of specimens containing egg, therefore all adults regarded as female. Amongst 25 females (ex Piccaninnie Ponds), 8 included 1 or 2 boli. Boli light or dark brown, homogeneously granular, level with or posterior to genital shields. Nine included single ellipsoidal egg with length within 70-92.5. Females with eggs appeared fatter but not longer than those without egg.

Material examined: Twenty-five females (N1979177-N1979201), litter and sparse grass, under *Acacia sophorae*, coastal scrubland, Piccaninnie Ponds, 3.7.1974 and 20.8.1975, D. C. Lee. Five females (N1979202-1979206) litter and sparse moss, under *Eucalyptus obliqua*, Mt. Lofty, 9.5.1974, D. C. Lee. Five females (N1979207-N1979211) litter, under *Pinus pinea*, Knott Hill, 22.5.1974, D. C. Lee.

Distribution: Argentina (NTc), Japan (Pc), South Australia (Aa). South Australia: Piccaninnie Ponds, coastal closed-scrubland, 35 (8/8); Mt. Lofty, sclerophyll open-forest, 13 (4/8); Knott Hill, cultivated pine forest, 6 (2/2).

Remarks: As the hysteronotal setae *J*1 and *J*2 are setose, they differ from the larger seta *J*3 that has lateral hyaline flaps giving it a lanceolate shape, which distinguishes *B. elsosneadensis* from all other possibly congeners except *B. elisabethae* (Mahunka, 1974: 211) from Rhodesia (Ee). *B. elsosneadensis* is distinguishable from *B. elisabethae* in having a conspicuous hysteronotal pore *hf*1 and narrower (breadth:length=0.3 or less:1) seta *J*3.

Brachychochthonius cricoides (Weis-Fogh)

(Fig. none)

Brachychthonius cricoides Weis-Fogh: 1948: 269.

Brachychthonius cricoides Weis-Fogh: Evans, 1952: 236.

Brachychochthonius cricoides (Weis-Fogh: Moritz, 1976b: 287).

Female

Shields pale straw-coloured. Idiosomal length 142.5 (5 ex Mt. Lofty and Knott Hill, 135-147.5); appendage lengths (for 145 ex Mt. Lofty)—*ch* 7.5, *pa* 20, *I* 45, *II* 40, *III* 42.5, *IV* 47.5; femur breadths—*pa* 6.25, *I* 10, *II* 8.75, *III* 8.75, *IV* 10. Specimens from Knott Hill have weak notal sculpturing, only a faint ridge associated with setal file *J*, a scalloped transverse ridge between tubercles bearing setae *J*6, and a line between setae *z*1 and *s*1. Specimens from Mt. Lofty have more complex notal sculpturing as illustrated for this species by Moritz, 1976b, but not as conspicuous as for *B. elsosneadensis*. Hysteronotal pore *hf*1 large, with conspicuous encircling refractile ring. One pale homogeneous granular bolus observed. Positors relatively small, involuted tubes forming a ring (diameter 10-12.5). No eggs seen, all adults assumed female.

Materials examined: Three females (N1979212-N1979214); litter and sparse moss, under *Eucalyptus obliqua*, sclerophyll forest, Mt. Lofty, 9.5.1974, D. C. Lee. Two females (N1979215, N1979216), litter, under *Pinus pinea*, Knott Hill, 22.5.1974, D. C. Lee.

Distribution: Denmark, Czechoslovakia, England, Germany, Italy, Sweden, Poland (Pe); Asiatic USSR (Ps); South Australia (Aa). South Australia: Mt. Lofty, scleropyll open-forest, 3 (2/8); Knott Hill, cultivated pine forest, 2 (1/2).

Remarks: B. cricoides is minute and pale, with faint sculpturing, short setose notal setae and a very conspicuous hysteronotal pore (*hf*1). The following 5 species are similar: *B. aokii* (Chinone, 1974); *B. jacoti* (Evans, 1952); *B. miyauchii* Chinone, 1978; *B. rotundatus* Hammer, 1958; *B. suecicus* Forsslund, 1942. B. cricoides is more precisely distinguishable in that it has rostral teeth, lacks fine punctuations in the median delineated areas of the proteronotal sculpturing, proteronotal seta *z*1 is without cilia and hysteronotal setae are short (*J*2 is about 0.35 × the distance between its bases; *J*3 is about 0.75 × the distance between its bases).

POECILOCHTHONIUS Balogh

Poecilochthonius Balogh, 1943: 22. Type designation (original): "*Poecilochthonius italicus* (Berl.)".

Poecilochthonius Balogh: Moritz, 1976b: 248.

Type-species: *Poecilochthonius italicus* (Berlese, 1910a: 220).

Diagnosis: Brachychthonius-complex. Hysteronotal shields without marginal longitudinal furrows, so that shield bearing setae *Z*1, *S*2, *Z*2, *Z*3 and *Z*4 not delineated from more central part. Two subnotal shields (*SNS*1, *SNS*3) separate from hysteronotal shields. Pair of merged coxites III and IV separated by fissure along mid-sternal line. Adanal seta *Ja*1 on broadly triangulate shield (width of broad anterior end = × 2.5 length of *Ja*1). Anterior 2 adanal setae in file *Za* conspicuously longer and/or stouter than *Za*3. Posterior setae in hysteronotal file *J* compacted forward, so that seta *J*6 in zone (breadth = × 0.5 distance *Z*5-*Z*6) centred on point midway between *Z*5 and *Z*6 in relation to posterior margin of hysteronotal shield.

Distribution: Widespread. Greenland (Nn); Argentina (NTc); Austria, Germany, Hungary (Pe); Italy, Yugoslavia (Pm); Japan (Pc); South Australia (Aa).

Remarks: Poecilochthonius species separate out to the couplet including *Brachychthonius* and *Synchthonius* in the key of Balogh (1972). No mites in the present study are grouped in this genus, but a species has been recorded from South Australia. Moritz (1976b) excludes 1 species, *Brachychochthonius hungaricus* (Balogh, 1943), originally included in this genus.

Three species are included in *Poecilochthonius: P. italicus* (Berlese, 1910a); *P. parallelus* (Womersley, 1945) **n. comb.**; *P. spiciger* (Berlese, 1910a).

Of the 2 specimens of *P. parallelus* from South Australia referred to by Womersley (1945), only the holotype (N1979297) has been found. Even after remounting, it remains strongly squashed around an axis that cuts through the region of setal file *S* on 1 side and *Za* and *Zg* on the other side. Despite this, 3 characters were observed on 1 side: subnotal shield *SNS*4 is absent; shield bearing seta *Ja*1 is broadly triangulate; adanal setae *Za*1 and *Za*2 are similar to each other and conspicuously stouter than *Za*3. Attributes of the hysteronotal sculpturing which gave rise to the name *parallelus* (i.e. the straight median and lateral ridges almost devoid of sculpturing in between) distinguish this species from its congeners.

LIOCHTHONIUS-complex

Diagnosis: Brachychthoniidae. Anterior subnotal shield (*SNS*1), bearing seta *S*1, merged with hysteronotal shield. Hysteronotal setae *Z*1, *S*2, *Z*2 and *Z*3 not in nearly straight line parallel to lateral margin of notal shield because seta *Z*2 displaced towards mid-notal line. Subnotal shield *SNS*3 separate, merged with hysteronotal shield or absent. Adoral seta *ao*2 either parallel sided with blunt distal end, setose or lanceolate. Two or 3 setae on either genu III or IV (ventral seta present or absent). Coxite IV bearing 4 setae.

Remarks: Except for *Synchthonius*, members of the *Liochthonius*-complex are hardly sculptured at all on their dorsal integument. *Synchthonius* does have seta *Z*2 displaced towards mid-notal line as on the unsculptured genera, but seta *J*6 is displaced anteriorad as for the sculptured genera of the *Brachychthonius*-complex. *Verachthonius* also has an anteriorad displacement of seta *J*6, although species have an almost smooth dorsal integument. Yet, there is a lateral ridge posteriorly around setae *Z*5 and *S*5, and sometimes a fainter 1 reaching *J*6. Possibly this ridge indicates that ancestors of this genus were more sculptured with the anteriorad displaced seta *J*6 on a tubercle.

Four genera are included in the *Liochthonius*-complex: *Liochthonius* van der Hammen, 1959; *Mixochthonius* Niedbala, 1972a; *Synchthonius* van der Hammen, 1952; *Verachthonius* Moritz, 1976a. Only *Liochthonius* and *Verachthonius* have been collected in South Australia and are considered below.

LIOCHTHONIUS van der Hammen

Brachychthonius Berlese: Strenzke, 1951: 235. Type indication: none, but 8 of 12 included species grouped in *Liochthonius* by Moritz (1976a), other 4 species not in *Brachychthonius*. Assume original designation of "*B. brevis* Mich.", although misidentification (Berlese, 1910a) of *Brachychthonius berlesei* Willmann, 1928 (Type of *Brachychthonius* Berlese, 1910a).

Liochthonius van der Hammen, 1959: 19. Type designation (original): "*Brachychthonius perpusillis* (redescription by Forsslund, 1942, p. 4, fig. 4)".

Liochthonius van der Hammen: Moritz, 1976a: 38. Type indication: "*Hypochthonius brevis* Michael, 1888 non Berlese 1910" (syn. *Brachychthonius perpusillus* Berlese, 1910a).

Type-species: *Liochthonius brevis* (Michael, 1888: 539).

Diagnosis: Liochthonius-complex. No subnotal shields separate from hysteronotal shields. Hysteronotal setae never conspicuously ciliate. Posterior setae in hysteronotal file *J* not conspicuously compacted forward, seta *J*6 nearer level of seta *Z*6 than point midway between *Z*5 and *Z*6 in relation to posterior margin of hysteronotal shield. Notal shields relatively smooth with few scattered circular markings. Only adoral seta (*ao*2) setose, tapering to distal point. Adanal seta *Za*2 conspicuously longer and stouter than other 2 setae (*Za*1, *Za*3). Three setae on both genu III and IV (ventral seta present). Aggenital file *Jg* with 4 setae (*Jg*4 present).

Distribution: Widespread, probably cosmopolitan.

Remarks: Liochthonius separates out correctly in the key of Balogh (1972). Species of all genera without a sculptured notum and with a centralward displaced seta *Z*2 have until recently (1972 and after) been grouped in *Liochthonius* despite the fact that, amongst a number of differences from the type of that genus, they have at least 1 separate subnotal shield: either *SNS*1 (*Neoliochthonius*) or *SNS*3 (*Mixochthonius, Verachthonius*) or both (*Neobrachychthonius*). This illustrates the fact that many brachychthoniids have until recently been classified on the basis of only a dorsal view of their soma. On the other hand, because of the strongly sculptured notal shields, the type of *Synchthonius* was previous grouped in *Brachychochthonius*, despite a centralward displaced seta *Z*2.

Niedbala (1972b) included 40 species in *Liochthonius*, but it is difficult to establish for certain how many nominal species should now be included in this genus. Moritz (1976a) includes 22 species from Europe and Chinone (1978) includes some of these plus a further 8 species from Japan. So that, with a minimum of 30 nominal species at the moment, it is likely that this is the largest genus in the Brachychthoniidae.

Niedbala (1977) used 37 morphological characters to calculate values of similarity amongst 19 species of *Liochthonius*. Whilst these species clustered into 4 separate groups, Niedbala concluded that establishing subgeneric taxa would be excessive splitting of the genus.

Moritz (1976a) divided *Liochthonius* into 4 species-complexes, which do not correspond to the groups noted by Niedbala (1977) and are mainly delineated by attributes of the notal setae. I have found it useful to use these species-complexes and a derivation from Moritz's key is presented below.

Key to species-complexes of *Liochthonius*

1. Hysteronotal setae broad, similar breadth to plasmic proteronotal seta *z*2 (*J*1 = × 0.75-× 1.25 *z*2) *horridus*-complex

   Hysteronotal setae setose, conspicuously slimmer than dilated distal half of plasmic proteronotal seta *z*2 (*J*1 = less than × 0.75 *z*2) 2

2. Plasmic proteronotal seta *z*2 distally spindle-shaped, with single terminal point and bearing 3 to 5 lateral files of 4 to 8 cilia ..... *brevis*-complex

   Plasmic proteronotal seta *z*2 distally bearing 2 lamellae, each with separate terminal point and 16 to 20 small marginal cilia 3

3. Notal setae mostly (always *z*1 and *J*3) setose, rounded in transverse section ..... *penduncularis*-complex

   Notal setae mostly (always *z*1 and *J*3) lanceolate, with narrow lateral lamellae, V-shaped in transverse section ..... *lapponicus*-complex

Members of the *lapponicus*-complex have not been collected in South Australia. Species of the *brevis*-complex and *horridus*-complex have been collected in the present study and are considered below, 1 species under each species-complex heading. A single species in the *penduncularis*-complex was collected previously from South Australia and is considered in the remarks on that species-complex.

brevis-complex

Liochthonius simplex (Forsslund)

(Fig. none)

Brachychthonius simplex Forsslund, 1942: 7.
Brachychthonius cf. *perpusillus* Berl.: Womersley, 1945: 219.
Liochthonius simplex (Forsslund): Moritz, 1976a: 50.

Female

Shields straw-coloured. Idiosomal length 162.5 (25 ex Knott Hill, 155-170); appendage lengths (for 162.5)—*ch* 14, *pa* 35, *I* 85, *II*55, *III* 50, *IV* 75; femur breadths—*pa* 8, *I* 13, *II* 11, *III* 11, *IV* 13. Specimens from Mt. Lofty similar in size, but 5 specimens from Normanville (Womersley 1945) sometimes larger (idiosomal length 152.5-205, previously recorded as 235, Womersley 1945), probably because squashed. No specimens contain eggs. Proteronotal plasmic setae *z*2 bears 5 lateral files of 4 to 6 cilia.

Material examined: Twenty-five females (N1979272-N1979296), litter, under *Pinus pinea,* Knott Hill, 22.5.1974; D. C. Lee. Five females (N1979298-N1979302) litter and sparse moss, under *Eucalyptus obliqua*, Mt. Lofty, 9.5.1974, D. C. Lee. Five females (N1979303-N1979307) form Normanville (Womersley 1945).

Distribution: Greenland (Nn); Czechoslovakia, England, Finland, Germany, Hungary, Poland, Sweden (Pe); Bulgaria (Pm); Asiatic USSR (Ps); Japan (Pc); South Australia (Aa). South Australia: Mt. Lofty, sclerophyll open-forest, 61 (6/8); Knott Hill, cultivated pine forest, 113 (2/2); Normanville (Womersley 1945).

Remarks: Moritz (1976a: 41) comments on *L.* cf. *perpusillus* (Berlese: Womersley, 1945) under *Liochthonius brevis* (Michael, 1888) stating that it is larger than the latter and with distinctly shorter dorsal setae. While I agree that this material should be grouped in the *brevis*-complex, Womersley's (1945) measurements for it are misleading and it fits better under *L. simplex* than *L. brevis* according to Moritz's (1976a) own descriptions. It should be noted that the proteronotal plasmic seta has to be examined carefully, since at certain angles it can appear to have the attributes of the *lapponicus*-complex, in which case this species might be grouped under *L mollis* (Hammer, 1958). Regarding the description of *L. simplex* by Chinone (1974), this appears to fit the description of *L. leptaleus* Moritz, 1976a rather than that of *L. simplex.*

horridus-complex

Liochthonius fimbriatissimus (Hammer)

(Fig. none)

Brachychthonius cf *horridus* Sellnick: Womersley, 1945: 220.
Brachychthonius fimbriatus Hammer, 1958: 14 (not Jacot, 1936: 248).
Liochthonius fimbriatissimus Hammer, 1962: 15.
Liochthonius fimbriatissimus Hammer: Hammer, 1966: 13.

Female

Shields straw-coloured. Idiosomal length 170 (25 ex Piccaninnie Ponds, 162.5-185); appendage lengths (for 177.5)—*ch* 13, *pa* 35, *I* 72.5, *II* 60, *III* 60, *IV* 75; femur breadths—*pa* 10, *I* 17, *II* 14, *III*14, *IV* 16. Form of some notal setae difficult to assess. Some notal setae (*j*1, *z*1, *J*6, *Z*6, *S*6) lanceolate with smooth-edged hyaline flaps. Other setae (e.g. *J*2-*J*5) appear similar, but hyaline flap sometimes wrinkled so that edge looks serrate. In contrast, seta *S*1 has hyaline flap of 1 side broken up into file of 6 distinct cilia. Other setae lanceolate in outline, but uncertain if edge ciliate or wrinkled. Positors present in all specimens examined and assumed females although no eggs seen. Of 25 specimens ex Piccaninnie Ponds, 16 contain 1 or 2 boli made up of material including distinct cellular forms.

Material examined: Twenty-five females (N1979218-N1979242), litter and sparse grass, under *Acacia sophorae,* coastal scrubland, Piccaninnie Ponds, 3.7.1974, D. C. Lee. Five females (N1979243-N1979247), litter and sparse moss, under *Eucalyptus incrassata,* Ferries-McDonald, 20.6.1974, D. C. Lee. Five females (N1979248-N1979252), litter, under *Banksia ornata,* Tamboore, 4.7.1974 D. C. Lee. Five females (N1979253-N1979257) litter and sparse moss, under *Eucalyptus obliqua,* Mt. Lofty, 9.5.1974, D. C. Lee. Five females (N1979258-N1979262), litter, under *Pinus pinea,* Knott Hill, 22.5.1974, D. C. Lee. Seven females (N1979263-N1979271) from Normanville (Womersley 1945).

Distribution: Argentina (NTa), Tierra del Fuego (Sm), New Zealand (An), South Australia (Aa). South Australia: Ferries-McDonald, mallee-broombush open-scrubland, 6 (3/8); Tamboore, mallee-heath tall open-shrubland, 68 (6/8); Piccaninnie Ponds, coastal closed-scrubland, 658 (8/8); Mt. Lofty, sclerophyll open-forest, 45 (4/8); Knott Hill, cultivated pine forest, 216 (2/2); Normanville (Womersley 1945).

Remarks: The leg I of *L. fimbriatissimus* is shorter and stouter than that of *L. simplex* described above. The top end of the range of idiosomal lengths given for *L. fimbriatissimus* (ex Piccaninnie Ponds) is probably too high since the specimens all belonged to a group which had been in lactic acid for a long time and were distended with extended chelicerae.

Moritz (1976a: 99) pointed out that *L.* cf *horridus* (Sellnick: Womersley, 1945) has shorter and stouter setae than *L. horridus* (Sellnick, 1928) and he excluded if from *L. horridus.* This material has been newly identified here as *L. fimbriatissimus* and the

many specimens from the present study have been similarly identified. They all look very much more like the illustration of this species (Hammer 1958: fig. 2) from Argentina rather than Womersley's illustration (Womersley 1945: fig. 1D-G). Hammer (1958) does figure the notal setae as almost parallel-sided compared to the more convex edges of those of the South Australian specimens, but this may result from the lateral hyaline flaps being angled up at their edges.

peduncularis-complex

Remarks: Members of the *peduncularis*-complex were not collected in this study. On the other hand, *Liochthonius longipilus* (Womersley, 1945: 220) **n.comb.** from Normanville, South Australia (holotype, N1979308: paratypes N1979309-N1979314) is grouped in this species-complex. The illustration (Womersley 1945: fig 1I) of the proteronotal plasmic seta *z*2 is inaccurate; it should be as for this species-complex. The following 2 more recently described species are very similar and 1 or both may be synonymous with *L. longipilus*.

Liochthonius ocellatus: (Hammer, 1958: 19) (**newly identified** as *L. longipilus)* from Argentina is not *L. ocellatus* (Hammer, 1952: 19) (syn. *L. hystricinus* by Moritz, 1976a: 66) from Canada. The subcircular markings and other characters on the notal surface of *L. longipilus* are similar to those illustrated for the Argentinian specimens. Therefore, since the Argentinian material has no valid name it is provisionally grouped under *L. longipilus*.

Liochthonius perfusorius Moritz, 1976a: 93 from Germany is very similar to *L. longipilus* although there are fewer notal markings illustrated.

VERACHTHONIUS Moritz

Verachthonius Moritz, 1976a: 112. Type designation (original): *"Brachychthonius laticeps* Strenzke, 1951".

Type-species: *Verachthonius laticeps* (Strenzke, 1951: 240).

Diagnosis: Liochthonius-complex. One subnotal shield (*SNS*3)separate from hysteronotal shield. Hysteronotal setae never conspicuously ciliate. Posterior setae in hysteronotal file *J* conspicuously compacted forward seta, *J*6 nearly level to point midway between *Z*5 and *Z*6 in relation to posterior margin of hysteronotal shield. Notal shields relatively smooth with few ridges or circles, usually 1 ridge runs from anterior notch between posterior notal and pleural shields back to region of seta *Z*5. Only adoral seta (*ao*2) stout, almost parallel-sided with blunt tip. Adanal setae *Za*1 and *Za*2 similar, either setose like seta *Za*3 or conspicuously stouter than *Za*3. Three setae on both genu III and IV (ventral seta present). Aggenital file *Jg* with 4 setae (*Jg*4 present).

Distribution: Canada (Nn), Argentina (NTc), Germany (Pe), Japan (Pc), Australia (Aa).

Remarks: Verachthonius species separate out to the couplet including *Brachychthonius* and *Synchthonius* in the key of Balogh (1972). But, because the descriptions of many speicies are mainly based on a dorsal view of the soma, any such incorrectly placed species of *Verachthonius* would probably be currently included in *Liochthonius* rather than *Brachychthonius* or *Synchthonius*.

Verachthonius montanus (Hammer, 1952: 17) from Canada and Argentine (Hammer 1958: 19), was included in *Eobrachychthonius* but on criteria used here it clearly belongs in the *Liochthonius*-complex and in either *Liochthonius* or *Verachthonius*. My most heavily weighted attribute for supporting its inclusion in *Verachthonius* is the forward displacement of seta *J*6.

Five species are included in *Verachthonius: V. congruus* Moritz, 1976a; *V. diversus* Moritz, 1976a; *V. laticeps* (Strenzke, 1951); *V. montanus* (Hammer, 1952), **n.comb.;** *V. moritzi* **n.sp.**

Verachthonius moritzi n.sp.

(Figs. 5-13)

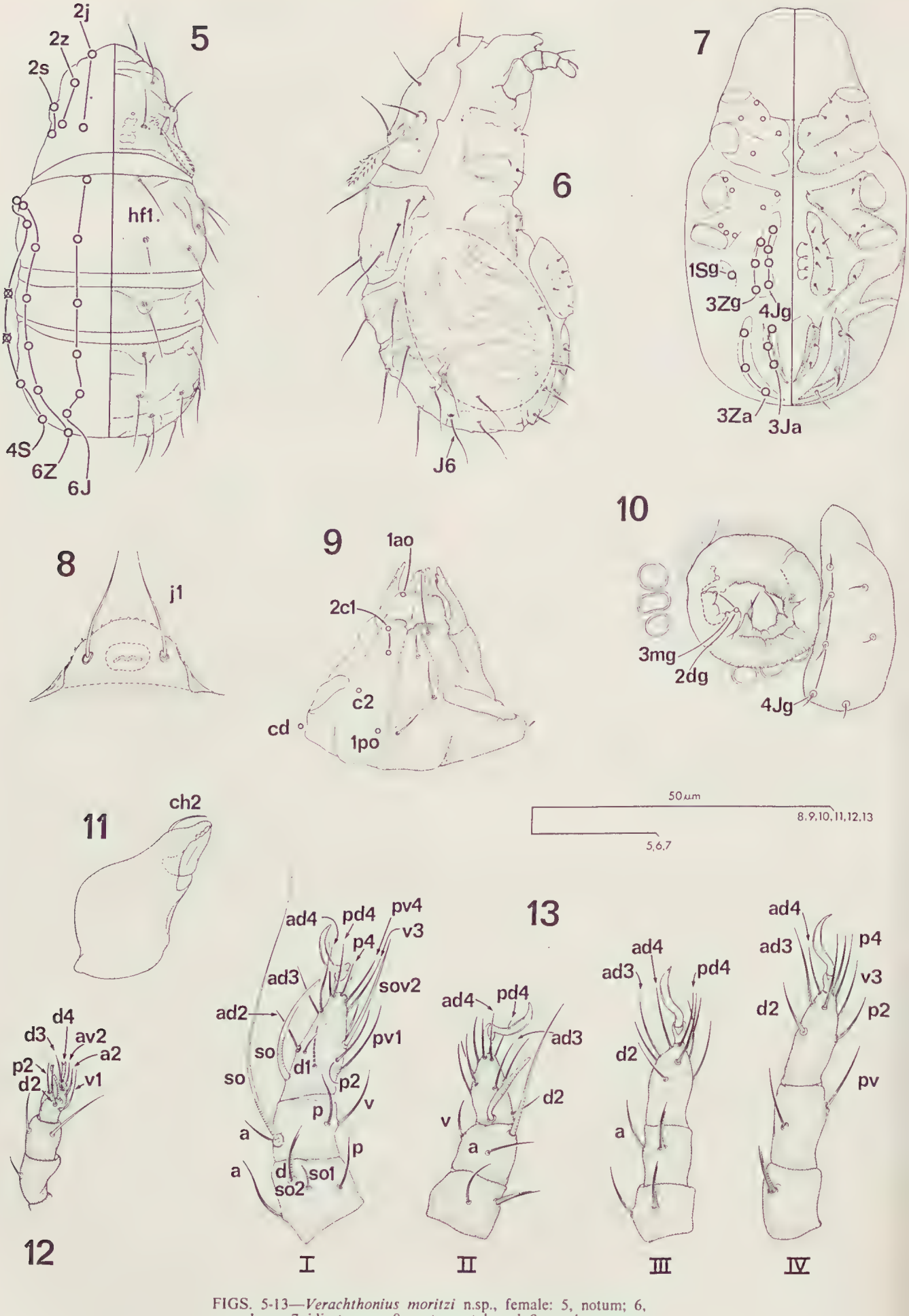
Female

General appearance: Shields straw-coloured. Idiosomal length 157.5 (20, 145-165); appendage lengths (for holotype, 152.5)—*ch* 10, *pa* 32.5, *I* 62.5, *II* 47.5, *III* 47.5, *IV* 62.5; femur breadths—*pa* 9, I 14, *II* 11, *III* 10, *IV* 11.

Prosternum: Gnathosoma illustrated either dorsoventrally squashed (Fig. 9) or laterally squashed so chelicerae unnaturally extended (Fig. 6). Single adoral seta (*ao*2) nearly parallel-sided for entire length, slightly spread out at blunt distal tip. External malae refractile and colourless. Coxites III and IV of each side clearly separated by mid-sternal fissure, but not established whether or not trough between coxites I and II occupied by striated cuticle.

Proteronotum: Single refractile recess under cowl shows through anterior part of proteronotal shield of cleared specimens. Seta *s*2 present, extremely minute and lying mid-way between a pore and *s*1. Plasmic seta *z*2 bears 5 files of 7 or 8 cilia on distal swollen part.

Opisthosternum: Genital and anal shields illustrated (Fig. 7) have lifted away from mid-sternal line, appear narrower. Adanal shields (bearing setal file *Za*) not posteriorly merged together. Transverse ridge on shield between setae Za2 and *Za*3. Ovipositors involuted, chaetotaxy difficult to observe. Ovipositor of holotype (contains egg) illustrated (Fig. 10) only 5 pairs of genital setae observed, possibly more present.



FIGS. 5-13—*Verachthonius moritzi* n.sp., female: 5, notum; 6, pleura; 7, idiosternum; 8, proteronotal cowl; 9, gnathosternum; 10, left genital shield and involuted ovipositor; 11, left chelicera, anterior surface; 12, part left palp, anterior surface; 13, legs, dorsal setae on genua, tibiae and tarsi.

Hysteronotum: Weak ridges on shields appear stronger as illustrated (Fig. 5) than they should be. Outlines of pleural and subnotal shields faint. Seta *S*5 on low tubercle.

Appendages: Chelicerae pale, not refractile, weakly dentate. Setae: *ch* (1), *pa* (0-2-1-3-9), *I* (0-3-3-4-17), *II* (0-4-3-3-14), *III* (2-3-3-3-11), *IV* (1-2-3-4-11). Solenidia: *pa* (0-0-1), *I* (2-1-3), *II* (1-1-1), *III* (1-1-0), *IV* (1-0-0). On tarsus I, only 1 solenidium in normal dorsal position, other 2 solenidia (*sov1* and larger *sov*2) ventral and spiniform. Solenidia on all genua and on tibia III coupled with setae. other dorsal solenidia separate. Absence of solenidium on tibia IV not known on other brachychthoniids.

Somal inclusions: Amongst 20 registered mites, 4 (2 from each site) contain single egg, rest without eggs. Eggs about 80 (70-82.5) long, ellipsoid with uniform smooth surface. Two specimens from Piccaninnie Ponds contain 11 and 18 small (diameter 20-25) spherical objects in hysterosoma which showed no internal structure and became very faint in gum chloral. Possibility that they were spermatophores or cysticercoids of anoplocephalid tapeworms considered and latter, if either, seemed more likely. Six specimens contained 1 or 2 boli, mainly granular, included some rectangular cellular forms.

Male

Unknown

Material examined: Holotype female (N1979315) and 13 paratype females (N1979316-N1979328), litter and sparse grass, under *Acacia sophorae,* coastal scrubland, Piccaninnie Ponds, 20.8.1975, D. C. Lee. Six females (N1979329-N1979334), litter, under *Pinus pinea*, Knott Hill, 22.5.1974, D. C. Lee.

Distribution: South Australia (Aa). South Australia: Piccaninnie Ponds, coastal closed-scrubland, 14 (4/8); Knott Hill, cultivated pine forest, 7 (1/2).

Remarks: Besides having more notal ridges than the other 4 nominal species, *V. moritzi* has conspicously longer notal setae, with seta *J*1 longer than half the distance between *J*1 and *J*2.

The centralward displacement of hysteronotal seta *Z*2 is not conspicuous for a member of the *Liochthonius*-complex, but it is more obvious if viewed at right-angles to the integument in the region of that seta or on squashed specimens.

NEOBRACHYCHTHONIUS-complex

Diagnosis: Brachychthoniidae. Anterior subnotal shield (*SNS*1), bearing seta *S*1, separate from hysteronotal shield. Hysteronotal setae *Z*1, *S*2, *Z*2 and *Z*3 not in nearly straight line parallel to lateral margin of notal shield because seta *Z*2 displaced towards mid-notal line. Subnotal shield *SNS*3 separate or merged with hysteronotal shield. Adoral seta *ao*2 either blunt or stout with swollen distal end. Chaetotaxy of genu III and IV unknown. Coxite IV bearing 3 setae.

Remarks: If the 2 genera included in this genus-complex had not been established, the species would probably be included in *Liochthonius* because of the position of *Z*2. So far they are only known from Europe (Pe). *Paraliochthonius* has to be renamed because its use for a pseudoscorpion genus has priority.

Two genera are included in the *Neobrachychthonius*-complex: *Neobrachychthonius* Moritz, 1976b; *Neoliochthonius* **n.name** for *Paraliochthonius* Moritz, 1976a not *Paraliochthonius* Beier, 1956.

Family TRICHTHONIIDAE n.fam.

Type-genus: *Trichthonius* Hammer, 1961.

Diagnosis: Hypochthonioidea. Minute to medium - sized (155-790), pale mites. Two complete transverse hysteronotal fissures (*TB*2, *TB*3); anterior fissure (*TB*2) never conspicuously closer to seta *J*2 than to *J*3, posterior fissure (*TB*3) about halfway between seta *J*1 and *J*6 or posterior to that level. Anterior part of pleural shield (*PS*1) either partially (less than × 0.6 breadth) separated off by vertical fissure or completely merged with posterior pleural shield (*PS*2). Hysteronotal setae vary considerably in length, setae *J*3 and *Z*3 more than × 2 length of setae *J*2 or *Z*2. Longer setae (*J*3, *J*4, *Z*3, *Z*4) setose with inconspicuous lateral cilia or linguiform with cilia and sometimes fringe of balloon-like structures, at least as long as distance between setal bases *J*1 and *J*4. Hysteronotal seta *S*2 not as near to mid-notal line as *Z*1. Each coxite of legs III and IV completely separate or only separate along mid-sternal line with III and IV merged on each side. No proteronotal eye or eyes in zone between setae *j*1 and *z*1. On tarsus I, seta *d*1 simple, setose or peg-like. Adoral file includes 1 (*ao2*) or 2 (*ao*2, *ao*3) setae.

Remarks: Trichthonius was grouped in the Cosmochthoniidae by Balogh (1972). But, in the classification presented in this paper, *Trichthonius* has to be grouped in the Retrofissurae rather than the Prof-issurae which includes Cosmochthoniidae. If the remarks on the Retrofissurae are studied, it can be seen by characters used there for the diagnosis of superfamiles, that *Trichthonius* must be included in the Hypochthonioidea. Within this superfamily, the Heterochthoniidae is the most suitable to include *Trichthonius,* on the other hand, the presence of a proteronotal eye or eyes in members of the Heterochthoniidae and the forward compression of the large spine-like hysteronotal setae and their shields, has made me reluctantly prefer to establish this new family, the Trichthoniidae.

Three genera are included in Trichthoniidae: *Marshallia* Gordeeva, 1980; *Nipponiella* Gordeeva, 1980; *Trichthonius* Hammer, 1961. *Trichthonius* has been collected in South Australia and is considered below. *Marshallia* includes 2 species: *M. majestus* (Marshall and Reeves, 1970) from North America; *M. golosovae* Gordeeva, 1980 from U.S.S.R. *Nipponiella* includes 1 species: *N. simplex* (Aoki, 1966) from Japan.

TRICHTHONIUS Hammer

Trichthonius Hammer, 1961; 15. Type designation (by monotypy); *"Cosmochthonius pulcherrimus* Hammer".

Type-species: *Trichthonius pulcherrimus* (Hammer, 1958: 22).

Diagnosis: Trichthoniidae. Most notal setae (including *j*2, *J*1, *J*2, *J*3, *J*4,) enlarged, linguiform, ciliate without fringe of balloon-like structures, and able to cover most of notum. Fifth rank of hysteronotal setae (*J*5, *Z*5, *S*5) conspicuously nearer to 6th rank than to zone midway between 4th and 6th ranks. Cheliceral seta *ch*2 conspicuous longer (× 1.2 or more) than fixed cheliceral digit. Two pairs of adoral setae (*ao*2,*ao*3). External malae bifurcate. Each coxite of legs III and IV completely separate. Chaetotaxy of genua: setae *I*-6, *II*-3, *III*-2, *IV*-3; solenidia *I*-1, *II*-1, *III*-1, *IV*-0.

Remarks: The single *Trichthonius* species is superficially very similar to members of the Cosmochthoniidae, especially to *Phyllozetes,* so it is understandable that it has been grouped in that family. Even the gnathosoma is considerably modified (a feature of Cosmochthoniidae), although not in a similar way and there is no conspicuous chitinous structure supporting enlarged pharyngeal muscles. The similarity is mainly due to the enlarged, erectile hysteronotal setae (*J*3, *J*4, *Z*3, *Z*4) which can lie close to the body or spread upwards like a peacock's tail. If the weighting of characters presented here is accepted, the similar characters must be regarded as resulting from convergent evolution. In contrast, *Trichthonius* looks rather different from the much larger, confamilial *Nipponiella,* with its almost simple notal setae and unmodified gnathosoma.

One species is included in *Trichthonius: T. pulcherrimus* (Hammer, 1958).

Trichthonius pulcherrimus (Hammer)

(Figs. 14-21)

Cosmochthonius pulcherrimus Hammer, 1958: 22.

Trichthonius pulcherrimus (Hammer): Hammer, 1961: 15.

Trichthonius pulcherrimus (Hammer): Hammer, 1962: 16.

Female

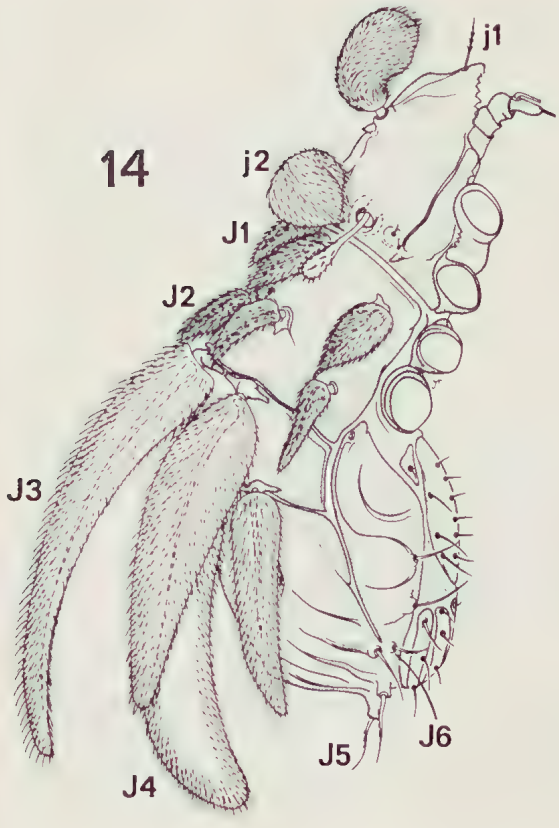
Shields ochre, covered by granulate adhesive layer. Idiosomal length 187.5, (4, 180-190); appendage lengths (for 185)—*ch* 13, *pa* 40, *I* 67.5, *II* 60, *III* 70, *IV* 77.5; tibial breadths—*I* 14, *II* 13, *III* 11, *IV* 13; femur breadths—*I* 14, *II* 13 *III* 14 *IV* 16. Tibial breadths given because trochanter and femur of legs III and IV disproportionately stout compared with rest of leg. Most notal setae subsemicircular in cross-section and possibly hollow with branched struts radiating from ventral midrib to convex dorsal surface. Only dorsal setal surface ciliate, seta *J*4 has dorsal bald patch which seta *J*3 rests on when collapsed down close to body. Erectile setae (*J*3, *J*4, *Z*3, and *Z*4) illustrated (Fig. 14) in intermediate position between lying close to body and being at right-angles to it. Many notal setae on tubercles with large spines. For seta *s*2, spine on tubercle larger than minute seta. Tubercles of 4 pairs of erectile setae carry 2 large, bifurcate spines, apparently articulating with spines of next erectile seta in same rank. Curiously, outward pointing spines of *Z*3 and *Z*4 fit this description although no other spines with which to articulate. Posteriorly, hysteronotal shield has central keel which setae *J*4 rest beside when lowered close to notum. On gnathosoma, adoral setae have rigid curved shaped, seta *ao*2 also has hyaline flap, external malae bifurcate with 2 slim, tapering branches. Chelicerae unusual. Movable digit appears foreshortened with anterolateral groove and large, hooked posterolateral process. Fixed digit edentate, may be movable. Seta *ch*2 large, curved with ventral hyaline flap. chelicerae has groove along anterolateral surface from the region of the mouth to base of movable digit. Pharynx appears simple and without conspicuous muscles sup ported by chitinous struts. On legs III and IV, trochanter, and to lesser extent femur, large and wrinkled.

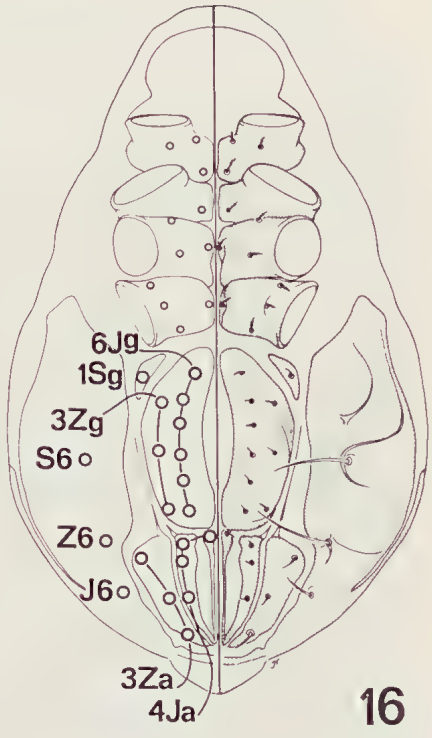
Appendage setae: *ch* (2), *pa* (0-2-1-3-10), *I* (1-3-6-6-19), *II* (0-4-3-5-17), *III* (2-3-2-4-15), *IV* (2-3-3-4-13). Solenidia: *pa* (0-0-1), *I* (1-1-1), *II* (1-1-2), *III* (1-1-0), *IV* (0-1-0). Solenidial form: baculiform on ta*pa*, ta*I*, ti*II*, ta*II*(*so*1 + *so*2); ceratiform on ge*II*, ge*III* ti*III*, ti*IV*; flagelliform with coupled seta on ge*I*, ti*I*.

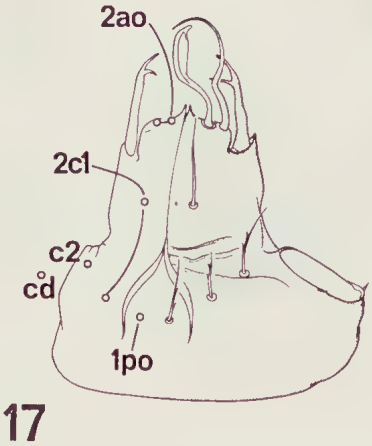
No somal inclusions (food boli or eggs) observed.

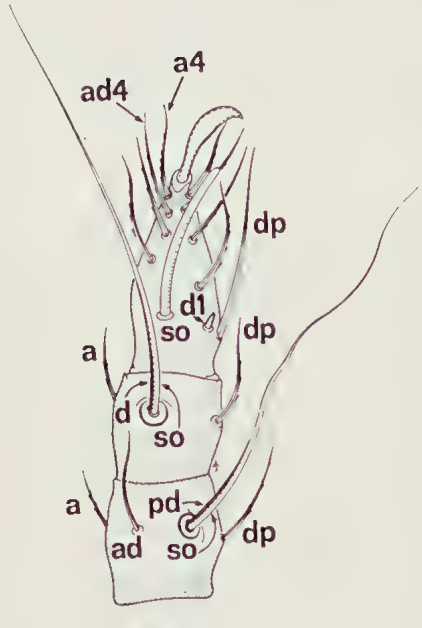
Material examined: One female (N1979335), litter or grass and moss, under *Eucalyptus viminalis,* Chambers Gully, 12.6.1974, D. C. Lee. Three females (N1979336-N1979338), litter and sparse moss, under *Eucalyptus obliqua,* sclerophyll forest, Mt. Lofty, 9.5.1974, D. C. Lee.

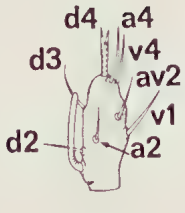
Distribution: Argentina, Bolivia, Chile, Peru (NTc); South Australia (Aa). South Australia: Chambers Gully, savannah woodland, 1(1/8); Mt. Lofty, sclerophyll open-forest, 3(2/8).

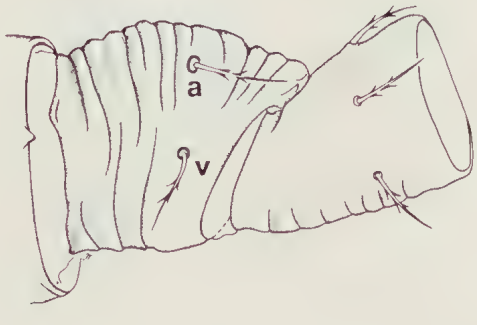


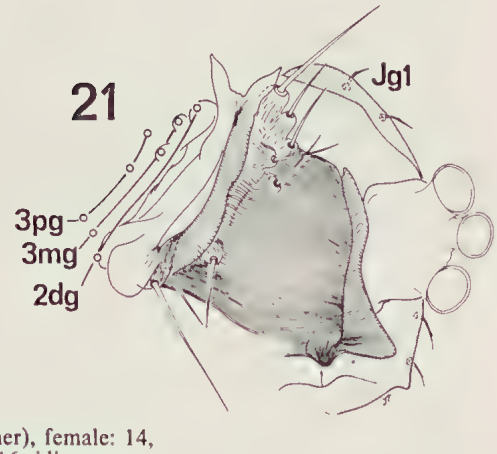


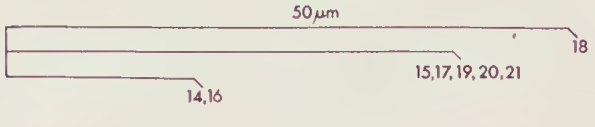












FIGS. 14-21—*Trichthonius pulcherrimus* (Hammer), female: 14, pleura; 15, right chelicera, anterior surface; 16, idiosternum; 17, gnathosternum; 18, left trochanter and femur IV, anterior and ventral surfaces; 19, right leg I, dorsal setae on genu, tibia and tarsus; 20, left palp tarsus, anterior surface; 21, left genital shield and ovipositor.

Remarks: There are differences between the description of the type material and the South Australian specimens, such as larger (230), proteronotal plasmic setz *z*2 not strongly dilated distally, hysteronotal seta *J*4 without dorsal bald patch, tibia I solenidium about half length of genu I solenidium. For the time being, these are regarded as either intraspecific variations or reflecting inaccurate illustration.

The gnathosoma is interesting in having primitive (only present in Bifemoratina and Retrofissurae) disjunct external malae and yet being considerably modified. The adoral setae and external malae appear to be modified to hold a globule of liquid and the chelicerae to provide a tube to suck up liquids. Unfortunately, there were no boli in the 4 specimens collected to give an indication of the nature of the food.

The shape of trochanter III and IV has not been used in the diagnoses of higher taxa. But the simple cylinder (Fig. 18), possibly given more mobility in *T. pulcherrimus* by being wrinkled, could be regarded as primitive, and within the Arthronotina be diagnostic of Retrofissurae. In contrast, *Cosmochthonius* has a modified trochanter (Fig. 24) which must give much more mobility to the leg, and could be diagnostic of Cosmochthonioidea.

Subcohort PROFISSURAE n.

Diagnosis: Arthronotina. Usually 3 transverse hysteronotal fissures (*TB*1, *TB*2, *TB*3), sometimes obscure as when notal setae umbellate (Pterochthoniidae), or when notum folded so that second fissure (*TB*2) covered by first hysteronotal shield (Sphaerochthoniidae), sometimes posterior fissures (*TB*2, *TB*3) partial (some Protoplophoridae), sometimes posterior fissure (*TB*3) absent (Sphaerochthoniidae). No hysteronotal gland with egress pore between setae *Z*4 and *Z*5. Cowl present, enclosing retracted chelicerae. Chelicerae often modified so that either fixed digit or seta *ch*2 comb-like; rarely seta *ch*1 absent in which case *ch*2 simple. Palp tarsus without distal bifurcate plasmic seta and often with 2 ribbon-like dorsal setae conspicuously longer than itself. External malae conjunct. Often conspicuous internal chitinous structure supporting enlarged pharyngeal muscles. One pair (*Zaf*) of adanal pores present. On tarsus I, seta *d*1 never bifurcate. No genua bear solenidia. Pretarsi usually with either 1 claw, 2 unequal claws (1 stout simple claw, 1 slim or ciliate claw) or 3 unequal claws (central stout claw, lateral slim claws), very rarely 2 subequal claws.

Remarks: The Profissurae is a new taxon. It has a diversity of form that reflects that of the Retrofissurae (see remarks on parallel evolution under Arthronotina). The name, Profissurae, is intended to indicate the main attribute which contrasts with Retrofissurae, i.e. that the anterior hysteronotal fissure (*TB*1) is always present.

The comb-like structure of the fixed cheliceral digit has been considered primitive in *Pterochthonius*, suggesting the origin of chelate chelicerae amongst Acari. This is unlikely. Probably, both it, the comb-like seta *ch*2 and other specializations of gnathosoma amongst Profissurae, function by sifting single-celled organisms from liquids. What is peculiar about these attributes is that they occur regularly amongst the Profissurae (whilst being absent elsewhere amongst Cryptostigmata) yet they may be either present or absent in very similar genera. This might lead to the conclusion that there were polymorphic forms or stages of the same species, but there is no support for this concept.

The attributes of pretarsal claws are used in the diagnosis although they are complex. The model is that, amongst Profissurae, pretarsi have a stout central claw, with slim lateral claws 1 or both of which may be lost especially on anterior legs, so that there should not be 2 subequal claws as on some other Arthronotina. The 1 known exception is *Cosmochthonius bengalensis* with 2 equally thick and curved claws on all pretarsi. The form of the claws of *Krivolutskiella* (Cosmochthoniidae) is not known, although they are unusual for the Profissurae in there being 2 claws on pretarsus IV.

The Profissurae includes 2 superfamilies: Cosmochthonioidea Grandjean, 1969; Protoplophoroidea Grandjean, 1965. The Protoplophoroidea includes 1 family as listed by Balogh (1972) and in relation to this study has been referred to (Lee 1981) under the now disbanded Arthroptyctima. The Cosmochthonioidea, some of which were also collected in this study, are considered further below.

Superfamily COSMOCHTHONIOIDEA

Diagnosis: Profissurae. Prehysteronotal fissure usually not hinged and never acutely hinged.

Remarks: The genera of Cosmochthonioidea as delineated here are very much as listed by Balogh (1972), except that the Pterochthoniidae are included. Grandjean (1954b: 334) drew attention to the remarkable similarity between members of this superfamily, particularly *Sphaerochthonius*, and the Protoplophoridae. In fact, whilst the Protoplophoridae was given quite a substantial diagnosis in my previous paper (Lee 1981: 212), if it was diagnosed here as a superfamily to be delineated from the Cosmochthonioidea, I would be confident only of giving its acutely hinged prehysteronotal fissure as a diagnostic attribute. Mahunka (1977b) established a new protoplophorid genus, *Hauseroplophora* from Kenya, which, because of its superficial similarity to *Sphaerochthonius*, he regarded as further supporting Grandjean's supposition. But in fact, although the form of its setae is similar to *Sphaerochthonius*, *Hauseroplophora* is not as similar as *Aedoplophora* and *Cryptoplophora*

(2 other genera of Protoplophoridae) are to *Sphaerochthonius* in the shape and disposition of the somal shields. Certainly, further study of established taxa within the Profissurae may indicate a broader basis for distinguishing the Protoplophoroidea from this superfamily. For example, *Sphaerochthonius* appears to share with *Cosmochthonius* the proximal construction of femur and trochanter IV, whilst these segments on members of the Protoplophoroidea are without such a constriction. On the other hand, a more thorough examination of *Sphaerochthonius* may indicate that it can, or originates from mites that could, fold up its soma around hinged fissures. This or other attributes may make the superfamily groups here redundant. Possibly, the present diverse Protophophoroidea represents a convergence from different evolutionary trends within the Cosmochthonioidea, but at this stage, I am adopting a conservative approach and maintaining it as in the classification of Balogh (1972).

The Cosmochthonioidea includes 4 families: Cosmochthoniidae Grandjean, 1946; Haplochthoniidae van der Hammen, 1959; Pterochthoniidae Grandjean, 1950b; Sphaerochthoniidae Grandjean, 1947a. The Haplochthoniidae and Pterochthoniidae were not represented in collections for this study and are not further considered.

Family COSMOCHTHONIIDAE Grandjean

Cosmochthoniidae Grandjean, 1946: 315.

Type-genus: *Cosmochthonius* Berlese, 1910.

Diagnosis: Cosmochthonioidea. Minute (240-360), ivory white to brown mites. Three complete, unobscured hysteronotal fissures (*TB*1, *TB*2, *TB*3). Four pairs of hysteronotal setae (*J*3, *J*4, *Z*3, *Z*4) long (at least as long as distance between setal bases *J*1 and *J*4) and erectile. Cowl broken up by 2 to 4 ranks of 4-9 longitudinal slits. Anterior subpleural shield (*SPS*1) has protruding ventral wing-like process, whilst subpleural shield (*SPS*2) has ventral extension to large pore. Genital tracheae present. Anterior cheliceral seta (*ch*2) pectinate with, 5 or 6 prongs. Tarsus I bears 1 solenidium. Tarsi I-IV with 2 or 3 claws.

Remarks: This widespread family, the Cosmochthoniidae, has very similar members grouped in 3 genera: *Cosmochthonius* Berlese, 1910; *Krivolutskiella* Gordeeva, 1980; *Phyllozetes* Gordeeva, 1978. Both *Cosmochthonius* and *Phyllozetes* have been collected in South Australia and are considered below. *Krivolutskiella* includes 1 species: *K. pubescens* Gordeeva, 1980 from the Canary Islands.

COSMOCHTHONIUS Berlese

Cosmochthonius Berlese, 1910a: 221. Type designation (original): "*C. lanatus* (Mich.)".

Type-species: *Cosmochthonius lanatus* (Michael, 1885: 396).

Diagnosis: Cosmochthoniidae. Some notal setae (*J*3, *J*4, *Z*3, *Z*4) long, stout, ciliate without broad leaf-like lateral membrane. Pretarsus I with 2 claws, pretarsi II, III and IV with 2 or 3 claws (2 subequal claws or stout central claw with 1 or 2 slim lateral claws). Coxites III and IV separate from each other. More setae on femur II and tarsi III and IV (6, 16 and 14).

Distribution: Widespread—Canada (Nn), California (Nc), Nevada (Nr); Bolivia, Argentina, Peru (NTc); Ghana (Ew); England, Germany, France, Russia (Pe); Italy (Pm); Russia (Ps); East Java (Om); Australia (Aa), New Zealand (An).

Remarks: Cosmochthonius is an easily recognised genus, but 2 species originally grouped in it are now combined in other genera. One, *Trichthonius pulcherrimus* (Hammer), see above, is here regarded as only superficially similiar, and is now in another subcohort (Retrofissurae). The other, *Phyllozetes emmae* (Berlese), see below, is similiar but was excluded by a restriction in the extent of the genus. The value of restricting the genus is questionable since the discovery of taxa with 2 claws on all legs: *Krivolutskiella* with some leaf-like hysteronotal setae (*J*3, *Z*3) like those of *Phyllozetes*; *Cosmochthonius bengalensis* with hysteronotal setae characteristic of *Cosmochthonius*.

Most descriptions of *Cosmochthonius* species are almost confined to the notal surface: exceptions are those of *C. reticulatus* by Grandjean (1962) and *C. fovealatus* as originally described. Having given new status to 3 subspecies, revoked a synonymy and named a previously described but unnamed species there are now listed below 15 species of *Cosmochthonius*. Gordeeva (1980) provides a key for 7 palaearctic species, which still leaves a problem for those wishing to identify *Cosmochthonius* from elsewhere. Since, in the past, notal sculpturing and the ciliation of the 4 large erectile setae (*J*3, *J*4, *Z*3, *Z*4) are the main diagnostic characters, I have used a unified terminology (see above under "Notation for Morphology") to briefly describe such attributes for all species. Some characters that differ from *C. australicus* (as described below) are also referred to. For convenience, the species are grouped in 4 species-complexes: *reticulatus*-complex, *foveolatus*-complex, *plumatus*-complex, *asiaticus*-complex.

reticulatus-complex

Diagnosis: Reticulate sculpturing covering posterior hysteronotal shield (*NS*4). Cilia on hysteronotal seta *J*3 even, usually short and sparse, rarely longer or medium spaced, between 14-38 on 1 side.

Remarks: Five species are included in the *reticulatus*-complex. The inclusion of *C. lanatus* is debatable.

Cosmochthonius bengalensis Chakrabarti *et al.*

Cosmochthonius bengalensis Chakrabarti, Bhaduri and Raychaudhuri, 1972: 86.

Length, 288-290 (ex West Bengal—Oi). Seta *z*1 unbranched. Seta *s*2 long, ciliate as *j*1. Seta *J*2 not on anterior ridge of second hysteronotal shield *(NS*2). Seta *J*3 with about 36 short sparse cilia on each side. Coxites I, II, III, IV with 3, 1, 3, 3 setae. Pretarsi I, II, III, IV with 2, 2, 2, 2 equally thick claws.

Cosmochthonius lanatus (Michael)

Hypochthonius lanatus Michael, 1885: 396.
Hypochthonius lanatus Michael, 1888: 541.
Cosmochthonius lanatus: Willmann, 1931: 101.

Length, 330 (ex England—Pe), 290-320 (ex Germany—Pe). Seta *z*1 unbranched. Seta *J*3 with more than 25 medium lengthed and medium spaced cilia on each side.

Remarks: Michael (1888) illustrates *C. lanatus* with large abutting puncta on the notum, but in the text states "notogaster is strongly and coarsely reticulated", also Willmann's (1931) illustration shows dorsal pits with distinctly straight edges. On the other hand, in Gordeeva's (1980) key (couplet 9/10), for *"Cosmochthonius* sp. *(lanatus?)"* the notal surface is described as having rounded abutting pits, and van der Hammen (1952) regards *C. domesticus* as synonymous with *C. lanatus*. Therefore the position of this poorly described species is uncertain.

Cosmochthonius reticulatus Grandjean

Cosmochthonius reticulatus Grandjean, 1947b: 354.
Cosmochthonius reticulatus Grandjean, 1962: 404.

Length, 300-340 (ex France—Pe). Cheliceral fixed digit with 5 well developed teeth, seta *ch*2 with 6 prongs. Transverse ridge between setal pair *j*1. Seta *s*2 long, ciliate (compared with *C. australicus)* although shorter and slimmer than other proteronotal setae. Plasmic seta *z*2 with distal half much stouter (× 6) than proximal half. Seta *J*2 not on anterior ridge of second hysteronotal shield *(NS*2). Seta *J*3 with 14 long sparse cilia on each side. Appendage setae and solenidia similar to *C. australicus* except tibia III with 5 and tarsus III with 15 setae.

Cosmochthonius sublanatus Mahunka

Cosmochthonius sublanatus Mahunka, 1977a: 254.

Length, 273-294 (ex eastern Java—Om). Seta *z*1 unbranched. Seta *s*2 long, ciliate as *j*2. Seta *j*3 with about 30 short medium spaced cilia on each side. Seta *z*3 with sparse cilia, *J*4 and *Z*4 shorter (× 0.5) than 3rd setal rank.

Cosmochthonius wallworki n.sp.

Cosmochthonius spec. *(C. lanatus?)* Wallwork, 1960: 386.

Length, 291 (ex Ghana—Ew). Seta *s*2 long, ciliate (compared with *C. australicus)* although shorter than other proteronotal setae. Plasmic seta *z*2 with distal half slightly stouter (× 1.5) than proximal half. Seta *J*2 on anterior ridge of second hysteronotal shield (*NS*2). Seta *J*3 with 18 short sparse cilia on each side.

foveolatus-complex

Diagnosis: Punctate sculpturing covering posterior hysteronotal shield (*NS*4). Cilia on hysteronotal seta *J*3 even, long and either sparse or dense, between 5-60 on 1 side.

Remarks: Six species are included in the *foveolatus*-complex. Three species *(C. domesticus, C. foveolatus, semiareolatus)* are similar to each other in having denser cilia and closer spaced puncta, and have been referred to as similar to *C. lanatus (reticulatus*-complex).

Cosmochthonius domesticus Grandjean

Cosmochthonius domesticus Grandjean, 1947b: 354.

Length, 245-285 (ex France—Pe). Cheliceral fixed digit with 4 teeth, central 2 inconspicuous, seta *ch*2 with 6 prongs. Form of cilia on hysteronotal seta *J*3 unknown. Puncta on posterior hysteronotal shield (*NS*4) large, circular or oval, never polygonal, and abutting.

Remarks: The synonomy of *C. domesticus* with *C. lanatus* (van der Hammen, 1952: 22) is revoked on the basis that it is not yet satisfactorily established.

Cosmochthonius foveolatus Beck n. status

Cosmochthonius lanatus foveolatus Beck, 1962: 232.

Length, 320-360 (ex Peru—NTc). Cheliceral fixed digit with 4 conspicuous teeth, seta *ch*2 with 5 prongs. Seta *z*1 unbranched. Ridge and tubercles connecting posterior margin of bothridia of plasmic setae *z*2. Seta *J*2 not on anterior ridge of second hysteronotal shield (*NS*2). Seta *J*3 with about 35 long, dense cilia on each side. Puncta on posterior hysteronotal shield (*NS*4) large, circular and abutting.

Cosmochthonius ponticus Gordeeva

Cosmochthonius ponticus Gordeeva, 1980: 844.

Length, 245 (ex Crimea—Pe). Seta *s*2 long, ciliate

(compared with *C. australicus)* although shorter than other proteronotal setae. Seta *J*3 with 5 or 6 medium lengthed cilia on each side near base. Puncta on posterior hysteronotal shield (*NS*4) large, irregular in outline and well separated.

Cosmochthonius semiareolatus Hammer

Cosmochthonius semiareolatus Hammer, 1966: 14.

Length, 285 (New Zealand—An). Seta *s*2 long, ciliate as *j*2. Seta *J*3 with about 60 long (longest in genus), dense cilia on each side. Puncta on posterior hysteronotal shield (*NS*4) large, circular and abutting.

Cosmochthonius tenuisetus Gordeeva

Cosmochthonius tenuisetus Gordeeva, 1980: 844.

Length, 245 (ex Crimea—Pe). Seta *s*2 long, ciliate (compared with *C. australicus)* although shorter than other proteronotal setae. Seta *J*2 long (reaches back to setal base *J*4). Seta *J*3 with 6 or 7 long, sparse cilia on each side, evenly spaced along seta. Puncta on posterior hysteronotal shield (*NS*4) small, circular and well separated.

Cosmochthonius ugamaensis Gordeeva

Cosmochthonius ugamaensis Gordeeva, 1980: 846.

Length, 290 (ex Uzbekistan—Ps). Seta *j*1 bifurcate, Y-shaped. Seta *s*2 long, ciliate as *j*2. Seta *J*2 not on anterior ridge of second hysteronotal shield *(NS*2). Seta *J*3 with 6 long, sparse cilia on each side, evenly spaced along seta. Puncta on posterior hysteronotal shield *(NS4)* large, star-shaped in outline and close although not abutting.

***plumatus*-complex**

Diagnosis: Punctate sculpturing covering posterior hysteronotal shield *(NS*4). Cilia on hysteronotal seta *J*3 uneven with both sparse long cilia and dense short (3 or 4 to each long cilium) cilia.

Remarks: Two species are included in the *plumatus*-complex, 1 of which is *C. australicus* collected in this study.

Cosmochthonius australicus Womersley n.stat.

(Figs. 22-29)

Cosmochthonius plumatus australicus Womersley, 1945: 222.

Female

Dull, ochre to orange. Cuticle covered in granulate hyaline adhesive layer which easily peels off. Refractile parts (external malae, cheliceral extremities, setae and claws) paler than general integument. Idiosomal length 280 (20 ex Ferries-McDonald, 275-285: others within this range); appendage lengths (for 280)—*ch* 15, *pa* 60, *I* 120, *II* 95, *III* 100, *IV* 115; femur breadths—*pa* 14, *I* 24, *II* 22.5, *III* 20, *IV* 20.

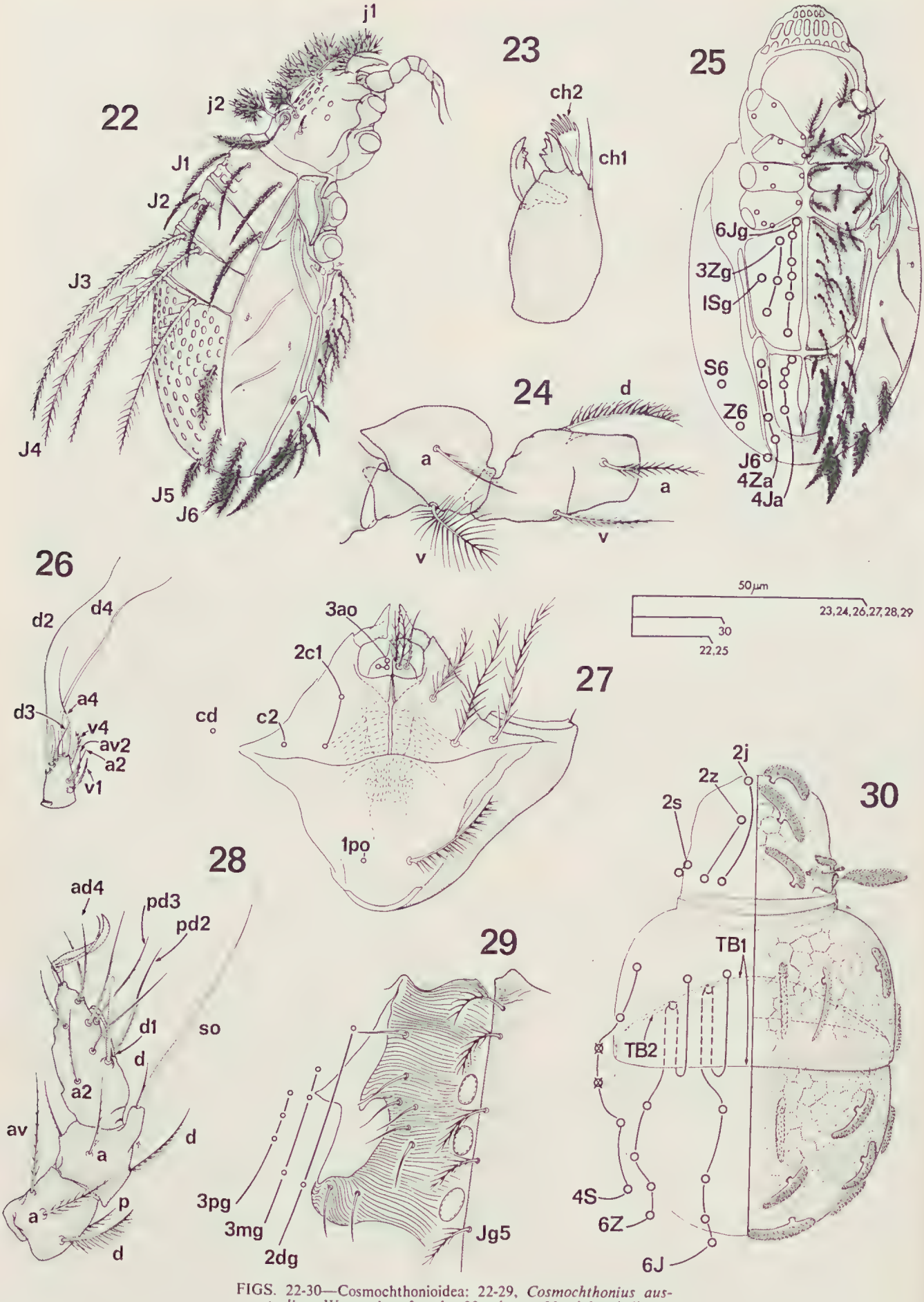
Puncta on posterior hysteronotal shield *(NS*4) large, circular and close although not abutting. On next shield *(NS*3), few very faint puncta not represented in illustration (Fig. 22). Few distinct puncta on second shield *(NS*2). On anterior shield *(NS*1), few rectangular pits. Setae *J*3, *Z*3, with about 24 long cilia and about 100 short cilia on each side. Setae *J*4, *Z*4 shorter with longer sparser long cilia. Proteronotal seta *z*1 bifurcate and T-shaped, with shorter posterior branch.

Cowl sometimes has 3 ranks of slits, posterior rank with 9 slits, middle rank with 7 slits, anterior rank with 5 slits, but arrangement may be more haphazard. Bases of conjunct external malae with central triangular flaps covering bases of internal malae and, with external malae, encompass oval aperture through which preoral setae protrude. Mentum undelineated, transverse ridge not regarded as mentocoxal fissure. Three wing-like processes on pleural and subpleural shields, lying above coxae III and IV. Posterior subpleural shield *(SPS*2) with ventral extension that becomes groove, lined with processes or hairs, leading to conspicuous pore behind coxa IV.

Chelicerae pale, fixed digit with 4 well developed refractile teeth. Trochanter IV and femur IV, to lesser extent same segments on leg III, unusual for primitive oribatids (possibly true for all Cosmochthonioidea) in being constricted proximally. These segments look as if they may be able to rotate around their proximal articulation, rather than rock backwards and forwards.

Appendage setae: *ch* (2), *pa* (0-2-1-3-11), *I* (0-5-5-6-19), *II* (1-6-5-6-17), *III* (2-3-4-4-14). Solenidia: *pa* (0-0-1), *I* (0-0-1), *II* (0-1-1), *III* (0-1-0), *IV* (0-1-0). Claws: I-2; II, III, IV-3. Cheliceral seta *ch* 2 with 6 prongs. Some setae on palp tarsus long and at least seta *d*4 ribbon-like and possibly plasmic. On tarsus I, plasmic seta *d*1 dilates slightly distally, curling around seta *pd*3. On tibia I, solenidium and coupled seta on conspicuous tubercle. Solenidia on posterior 3 pairs of legs ceratiform, those on tibiae (especially tibia IV) small. Positor short, but too large to be male, although all genital setae appear similar in size.

Conspicuous internal chitinous structures encompass pharynx between level of preoral and postoral setae, also ovoid refractile membrane (not illustrated) arises in region of palp coxite and extends backwards to coxite II, probably equivalent of "*vpx*" (Grandjean 1948: fig. 3A). Genital tracheae extend forward from anterior end of genital orifice. Gut contents consist entirely of dark green granular material and refractile spheres (diameter, 2-3). Narrow pharynx expands about level of seta *J*2 into fat horseshoe-shaped pair of dorsal diverticulae that loop backwards around



FIGS. 22-30—Cosmochthonioidea: 22-29, *Cosmochthonius australicus* Womersley, female; 22, pleura; 23, right chelicera, anterior surface; 24, left trochanter and femur IV, anterior and ventral surfaces; 25, idiosternum; 26, left palp tarsus, anterior surface; 27, gnathosternum; 28, right leg I; 29, left genital shield and ovipositor; 30, *Sphaerochthonius splendidus* (Berlese), notum.

lateral margins of hysteronotum. Dorsal diverticulae often uniformly full of food. At anterior end of horse-shoe-shape (between level of setae *J*2 and *J*3) gut inclines ventralwards to anus. This strip of straight gut usually contains 2 or 3 boli, anterior bolus being diffuse and larger whilst posterior bolus smaller (diameter, about 25) and dense. No eggs observed inside mites.

Material examined: Lectotype (N1979378) and 2 paralectotypes (N1979379-N1979380), moss, Mt. Arden, southern Flinders Ranges, 11.1943, H.M. Cooper. Twenty females (N1979339-N1979358), litter and sparse moss, under *Eucalyptus incrassata,* mallee scrubland, Ferries-McDonald, 20.6.1974, D.C. Lee. Six females (N1979359-N1979364), grass and moss or litter under *Eucalyptus viminalis,* savannah woodland, Chambers Gully, 12.6.1974, D.C. Lee. Twelve females (N1979365-N1979376), litter and sparse moss, under *Eucalyptus obliqua,* sclerophyll forest, Mt. Lofty, 9.5.1974, D.C. Lee. One female (posterior half) (N1979377), grass and plantain, Glenthorne, 12.6.1974, D.C. Lee.

Distribution: South Australia (Aa). South Australia: Ferries-McDonald, mallee-broombush open-scrubland, 20(3/8); Chambers Gully, savannah woodland, 6(3/8); Mt. Lofty, sclerophyll open-forest, 12(4/8); Glenthorne, cultivated pasture, 1(1/8); Mt. Arden and Waterfall Gully (Womersley, 1945).

Remarks: Regarding the collection data, the record of 1 specimen from Glenthorne is based on a hysterosoma alone, but from its condition it is assumed that the mite was damaged after collection. The original 6 specimens from Waterfall Gully cannot be found. Instead of the 2 specimens, as originally recorded from Mt. Arden, there are 3 specimens with exactly the same labels. The specimen designated as the lectotype is the specimen drawn (Womersley, 1945: fig. 2) on the basis of the position of hysteronotal setae. One specimen designated as a paralectotype cannot belong to the published syntype series, but, since it is not known which one, this has to be disregarded.

The original description (Womersley, 1945) is inaccurate for a number of attributes, for example the form of the cilia on hysteronotal setae *J3, J4, Z3, Z4* and the presence of punctuations on the third hysteronotal segment (*NS*3). Since these inaccuracies apply to the main 2 groups of characters used in diagnosis, it highlights the need for this genus to be reviewed by someone with type specimens before him rather than only descriptions in the literature.

Cosmochthonius australicus can be distinguished from *C. plumatus,* the only other member of the species-complex, by the form of the hysteronotal puncta. On the other hand, these puncta are similar to those of some members of the *foveolatus*-complex which also have seta *J3* with even, dense, long cilia.

The gnathosoma of this species, as that of a number of other members of the Profissurae, is unusual, as initially described by Grandjean (1948 and 1954b). The ribbon-like palp setae and the comb-like cheliceral seta suggest that the food is swept out of a liquid, possibly with the slits in the cowl also acting as a sieve. Whilst the structures at the anterior end of the pharynx may be a crushing or suctorial mechanism. On the other hand, although in South Australia *C. australicus* is recorded from moister regions, mallee scrubland is not an environment in which free water is often present.

Cosmochthonius plumatus Berlese

Cosmochthonius plumatus Berlese, 1910: 221.
Cosmochthonius plumatus: Grandjean, 1950a: 78.

Length, 300 (ex Italy—Pm). Cheliceral fixed digit with 4 well developed teeth, seta *ch*2 with 6 prongs. Seta *s2* with long cilia. Seta *J*3 form only partially known, but cilia uneven with sparse long cilia and dense short cilia. Puncta on posterior hysteronotal shield (*NS*4) small, varying in size and well separated.

asiaticus-complex

Diagnosis: No sculpturing covering posterior hysteronotal shield (*NS*4). Cilia on hysteronotal seta *J3* even, long and sparse, between 8-22 on 1 side.

Remarks: Two species are included in the *asiaticus*-complex. One species (*C. suramericanus)*, because it apparently has only 1 claw on each of its pretarsi, may be based on a nymph.

Cosmochthonius asiaticus Gordeeva

Cosmochthonius asiaticus Gordeeva, 1980: 846.

Length, 319 (ex Tadzhikstan—Ps). Seta *s*2 long, ciliate as *j*2. Seta *J*2 long (reaches back almost to setal base *J*4). Seta *J*3 with 8 long, sparse cilia on each side, evenly spaced along seta.

Cosmochthonius suramericanus Hammer n.stat.

Cosmochthonius plumatus suramericanus Hammer, 1958: 23.

Length, 220 (ex Argentina—NTc). Seta *s*2 long, ciliate as *j*2. Seta *J*3 with about 25 long, sparse cilia on each side.

PHYLLOZETES Gordeeva

Phyllozetes Gordeeva, 1978: 1099. Type designation (original): *"Cosmochthonius emmae* Berl., 1910".

Type-species: *Phyllozetes emmae* (Berlese, 1910: 222).

Diagnosis: Cosmochthoniidae. Some notal setae (*J*3, *J*4, *Z*3, *Z*4) long, stout, leaf-like with broad lateral membrane bearing marginal cilia. Pretarsi I, II and III with 2 claws (stout central claw, slim anterior claw), pretarsus IV with 3 claws. Coxites III and IV merged together. Fewer setae on femur II and tarsi III and IV (5, 13 and 12).

Distribution: Widespread—Texas (Nr); France, east Crimea (Pe); Algeria, Austria, Greece, Hungary, Italy (Pm); Japan (Pc); India (Oi); Komodo Islands (Am); South Australia (Aa).

Some literature suggests that species are found in humus amongst trees or in moist ground even if poor in organic material. But *Phyllozetes* is also recorded from rapid draining sandy soil with depleted vegetation. In South Australia it was collected in a fairly dry sandy area, as well as from moister sites, 1 having a substantial humus layer.

Remarks: Phyllozetes is certainly closely allied to *Cosmochthonius* and *Krivolutskiella.* It may in the future prove preferable to group these genera together.

The name *"Ovochthonius"* is used in combination with *P. emmae* by Mahunka (1980: 110) with the authority of Gordeeva 1978: 1099. This is presumed to result from confused communication, since *Ovochthonius* Ryabinin in Ryabinin and Krivolutzky, 1977 is grouped in the Heterochthoniidae.

Five species are included in *Phyllozetes: P. emmae* (Berlese, 1910); *P. hypoquercus* McDaniel and Bolen, 1980; *P. latifolius* Gordeeva, 1980; *P. osithchnjukovi* Gordeeva, 1980; *P. tauricus* Gordeeva, 1978.

The specimens collected in this study are grouped in *P. emmae.* Because it is difficult to delineate this species, the other 4 species are briefly described. *P. hypoquercus:* length, 285 (ex Texas—Nr); seta *j*1 Y-shaped; setae *J*2-*J*2 close (× 0.5 *J*2-*Z*2); setae *J*3, *Z*3 similar to *J*4, *Z*4, with short, dense marginal cilia (over 50 on 1 side), coxites I, II, III, IV with 3, 3, 3, 3 setae. *P. latifolius:* length, 150 (ex Canary Islands—Pm, Crimea—Pe); seta *j*1 unbranched; setae *J*2-*J*2 close (× 0.5 *J*2-*Z*2); setae *J*3, *Z*3 narrower, with short, medium spaced marginal cilia (about 32 on 1 side); setae *J*4, *Z*4 broader, with long, medium spaced marginal cilia (about 32 on 1 side); number of setae on coxites unknown. *P. osithchnjukovi:* length, 160 (ex Russia—Pe); seta *j*1 unbranched, setae *J*2-*J*2 with bases touching (less than × 0.1 *J*2-*Z*2); setae *J*3, *Z*3 narrower, with short, dense marginal cilia (about 55 on 1 side); setae *J*4, *Z*4 broader, with medium lengthed and long, medium spaced marginal cilia (about 35 on 1 side); number of setae on coxites unknown. *P. tauricus:* length, 285 (ex Crimea—Pe); seta *j*1 Y-shaped, seta *J*2-*J*2 widely spaced (× 0.8 or more *J*2-*Z*2); setae *J*3, *Z*3 narrower, with long sparse marginal cilia (about 15 on 1 side); *J*4, *Z*4 broader, with long, sparse marginal cilia (about 17 on 1 side), coxites I, II, III, IV with 3, 3, 3, 3 setae.

Phyllozetes emmae (Berlese)

(Fig. none)

Cosmochthonius emmae Berlese, 1910: 222.
Cosmochthonius emmae Berlese: Mahunka, 1977: 254.
Ovochthonius emmae (Berlese): Mahunka, 1980: 110.
Phyllozetes emmae (Berlese): Gordeeva, 1980: 849.

Female

Ivory-white to pale straw-coloured. Cuticle covered by dirty, hyaline, adhesive exudate. Idiosomal length 200 (4, 187.5-210); appendage lengths (for 187.5 ex Piccaninnie Ponds)—*ch* 11, *pa* 40, *I* 72.5, *II* 57.5, *III* 60, *IV* 72.5; femur breadths—*pa* 10, *I* 19, *II* 18, *III* 15, *IV* 15.

Hysteronotal shields appear to lack sculpturing. Proteronotal seta *j*1 bifurcate (Y-shaped), seta *z*1 bifurcate (T-shaped) with posterior branch about X0.5 length of anterior branch. Hysteronotal setal pair *J*2 almost (X0.8 or more) as far apart as distance between setal bases *J*2-*Z*2. Anterior erectile setae (*J*3, *Z*3) with lateral lamellae gradually tapering, and long, dense to medium spaced cilia along margin (about 30 on 1 side). Posterior erectile setae (*J*4, *Z*4) with broader gradually tapering lateral lamellae, and long, dense to medium spaced cilia along margin (32-35 on 1 side). Shape of most other somal setae similar to that of *P. tauricus.* Coxites I, II, III, IV with 3, 2, 3, 4 setae. Central margin of genital shield with 6 *Jg* setae. Chaetotaxy and solenidiotaxy of appendages similar to *C. australicus,* except femur II has only 5 setae (seta a absent), tarsus III has only 13 setae (setae *p*2, *pv*2, *v*3 absent), tarsus IV has only 12 setae (setae *pv*2, *v*3 absent). Claws: I, II, III-2; IV-3.

Gnathosoma, internal structures around pharynx, genital tracheae, structure of alimentary canal and contained food, ovipositor, all similar to those of *C. australicus.*

Material examined: Two females (N1979383 and N1979384), litter and sparse moss, under *Eucalyptus incrassata,* mallee scrubland, Ferries-McDonald, 20.6.1974, D. C. Lee. One female (N1979382), litter, under *Banksia ornata,* mallee-heath shrubland, Tamboore, 4.7.1974, D. C. Lee. One female (N1979381), litter and sparse grass, under *Acacia sophorae,* coastal scrubland, Piccaninnie Ponds, 20.8.1975, D. C. Lee.

Distribution: Uncertain because of difficulty of identification. Possibly Palaearctic and Australian regions. South Australia: Ferries-McDonald, mallee-broombush open-scrubland, 2 (1/8); Tamboore, mallee-heath tall open-shrubland, 1 (1/8); Piccaninnie Ponds, coastal closed-scrubland, 1 (1/8).

Remarks: Specimens regarded as *P. emmae* are described from 3 localities other than the type material and that from South Australia. These descriptions are almost limited to 2 erectile hysteronotal setae (*J*3 and/or *J*4) and they show considerable variation. On the original illustration of the type (Berlese 1910: fig. 49) from Italy (Pm), the erectile hysteronotal setae have marginal cilia which are so short and dense they are hardly discernable. On the other hand Mahunka's (1980: figs. 11, 12) illustrations of these setae shows the marginal cilia as long and medium-spaced to sparse (22-27 on 1 side) with seta *J*4 slightly bigger but similar to *J*3. Mahunka's (1977: fig. 9) illustration of *J*3 or *J*4 on a specimen from Vienna (Pe) is similar to this latter description of the type. Seta *J*3 or *J*4 on a specimen from Komodo Island (Am) (Mahunka 1977: fig. 8) has short dense marginal cilia (about 56 on 1 side) and is almost parallel sided with an acutely tapering tip, therefore, it is excluded from *P. emmae*. Specimens from the Crimea (Pe) (Gordeeva 1980: figs. 5, 6) have short medium spaced marginal cilia (29-31 on 1 side) and should possibly also be excluded from *P. emmae*.

In identifying the South Australian specimens, Mahunka's (1980) redescription of the type is accepted, and the fact that there are more and denser marginal cilia on setae *J*3 and *J*4 is regarded as an intraspecific variation. A more comprehensive redescription of the type may require that a new species be established for this material.

Family SPHAEROCHTHONIIDAE Grandjean

Sphaerochthoniidae Grandjean, 1947a: 224.

Type-genus: *Sphaerochthonius* Berlese, 1910

Diagnosis: Cosmochthonioidea. Minute (237.5-375), whitish to brown mites. One complete hinged hysteronotal fissure (*TB*1) present; second hysteronotal fissure (*TB*2) just posterior to seta *J*2, but obscured by anterior hysteronotal shield (*NS*1); 3rd hysteronotal fissure (*TB*3) present on larva or some nymphs in region of seta *J*3, rarely represented on adult, although sometimes transverse dorsal ridges near setae *J*3 and *J*4. No hysteronotal setae erectile or long (not as long as distance between setal bases *J*1 and *J*4) and, except setae *J*2 and *Z*2, all ciliate and seta *Z*1 T-shaped. Setae *J*2 and *Z*2 simple, shorter than distance between setal bases *J*2-*J*2, and normally under anterior hysteronotal shield. Cowl without longitudinal slits. Anterior cheliceral seta (*ch*2) pectinate with 3 prongs. Tarsus I bearing 3 solenidia. Tarsi I-IV with 3 claws.

Remarks: Despite the superficial lack of similarity between the Sphaerochthoniidae and the Cosmochthoniidae, they have usually been regarded as closely allied. Also (see above in the remarks on the Cosmochthonioidea) Sphaerochthoniidae has long been regarded as allied to the Protoplophoridae although this is not reflected in the classification by Balogh (1972). Regarding the relationship of the Sphaerochthoniidae and Protoplophoridae, the nature of the prehysteronotal fissure is an important character commented on in the remarks on *Sphaerochthonius splendidus*.

The Sphaerochthoniidae includes only a single genus: *Sphaerochthonius* Berlese, 1910a.

SPHAEROCHTHONIUS Berlese

Sphaerochthonius Berlese, 1910: 223. Type designation (original): "*Hypochthonius splendidus* Berl.".

Type-species: *Sphaerochtonius splendidus* (Berlese, 1904: 26).

Diagnosis: Sphaerochthoniidae (monogeneric).

Distribution: Widespread—Canada (Nn), California (Nc); Brazil (NTc); Ghana (Ew); Somali (Ee); Caucasus, Crimea (Pe); Algeria, Greece, Italy, Morocco (Pm); Japan (Pc); Java (Om); Komodo Island (Am); South Australia (Aa).

Remarks: Sphaerochthonius is an easily recognisable genus, but delineating the included species is difficult. The unusually small specimen before me has been placed in the type-species, *S. splendidus*, which was originally described from the Mediterranean region. The reason for this placement is partly because the poor descriptions of a long established species make it less exclusive. In order to give some idea of the degree of similarity of the South Australian specimen to other species, I have given a short description of the other species.

In describing *S. suzukii*, Aoki (1977) has reviewed the genus, especially with regard to the form of the somal setae. In referring to hysteronotal setae *J*2 and *Z*2 (as *d*1 and *d*2), he regards the fact that they are short and simple as diagnostic of *S. suzukii*. In fact this attribute is true for the South Australian specimen, the larva of an unnamed species (Grandjean 1934: fig. 2) and for *S. sublanatus* (Mahunka 1977a: fig. 7). In the case of *S. sublanatus* and *S. suzukii*, the mite drawn is slightly squashed and the anterior hysteronotal fissure (*TB*1) has opened up so that setae *J*2 and *Z*2 are no longer obscured by the anterior hysteronotal shield. On the illustrated specimen of *S. suzukii*, the second hysteronotal shield (*NS*2) appears fused to shield *NS*3, whilst for *S. sublanatus* it is attached to shield *NS*1. It is likely that in other species where setae *J*2 and *Z*2 are obscured they have not been described and so what Aoki (1977) would regard as setae *J*2 and *Z*2 are in fact *J*3 and *Z*3.

The 7 species included in *Sphaerochthonius* are considered below mainly in alphabetical order but

with *S. splendidus*, in which the South Australian specimens are grouped, last.

Sphaerochthonius gemma (Oudemans)

Hypochthonius gemma Oudemans, 1909: 319.
Sphaerochthonius elegans Berlese, 1910: 266.
Cosmochthonius gemma (Oudemans): Oudemans, 1917: 25.
Sphaerochthonius gemma (Oudemans): van der Hammen, 1959: 26.

All specimens regarded as nymphs since few genital setae and only 1 claw on each of its pretarsi. Length, 268 (ex Java—Om). All illustrated notal setae, except *z*2, T-shaped, ciliate and stick-like. Two branches of hysteronotal setae subequal in length. Setae in hysteronotal ranks, 3, 4 and 5 with horizontal branches directed transversely. Two heavy lines in illustration (Oudemans 1917: fig. 51) run through setae *J*3 and *J*4 and I agree with Grandjean (1932a: 34) that they represent dorsal ridges, because posterior line would otherwise have to be a 4th fissure.

Sphaerochthonius longisetus Mahunka

Sphaerochthonius longisetus Mahunka, 1977a: 256.

Length, 360-374 (ex Komodo Island—Am). Many dorsal setae (*j*1, *j*2, *J*1, *Z*1, *S*1, *S*2, *Z*4, *J*5, *S*5)T-shaped, papillose and leaf-like. Seta *j*1 similar but ciliate. Setae *s*1, ?*s*2, *J*3 and *Z*3 unbranched, papillose and stick-like; seta *J*3 unusually long (about distance between setal bases *Z*1-*Z*2).

Sphaerochthonius phyllophorus Balogh and Mahunka

Sphaerochthonius phyllophorus Balogh and Mahunka, 1969: 32.

Length, 289-319 (ex Brazil—NTb). Setae *J*1, *z*1, *j*2 T-shaped and possible intermediate between stick-like and leaf-like. "Anterior" hysteronotal setae T-shaped, papillose and leaf-like. "Posterior" hysteronotal setae unbranched, papillose and leaf-like.

Sphaerochthonius suzukii Aoki

Sphaerochthonius suzukii Aoki, 1977: 85.

Length, 310 (ex Japan—Pc). Most notal setae ciliate (short, blunt cilia) and stick-like. Setae *j*1, *z*1, *J*1, *Z*1, *S*1, *S*2, *J*5, *Z*5, *S*5, *J*6 T-shaped, whilst *s*1, *j*2, *s*2, *J*3, *Z*3, *Z*4 unbranched. Setae *Z*6 and *S*6, like setae in file *Za*, unbranched, slim with long, tapering cilia. Transverse dorsal ridge passes just posterior to seta *J*3.

Sphaerochthonius transversus Wallwork

Sphaerochthonius transversus Wallwork, 1960: 377.

Length, 256-277 (ex Ghana—Ew). Form of notal setae similar to *S. gemma* , especially since horizontal branches of setae *J*3 and *Z*3 directed transversally (not an artifact, occurs on living specimens) and 2 branches of each seta similar in length. Different, since setae *s*1 and *j*2 unbranched. Apparently dorsal ridge associated with 3rd hysteronotal setal rank, no such ridge associated with 4th rank as on *S. gemma*. Nymphs grouped in this species have long seta *J*3 like *S. longisetus* and may not be conspecific.

Sphaerochthonius wallworki n.sp.

Sphaerochthonius spec. Wallwork, 1960: 382.

Length, 298 (ex Ghana-Ew). As pointed out in original description, this species very similar to *S. gemma*, having 2 transverse dorsal ridges passing along 3rd and 4th hysteronotal setal ranks, and mainly T-shaped, ciliate, stick-like setae. On the other hand, seta *j*2 unbranched and horizontal branches of setae *J*3 and *Z*3 directed longitudinally with shorter anterior branch. Nymph grouped in this species with horizontal branches of setae *J*3 and *Z*3 directed transversely as *S. gemma*. Despite 4 setae in file *Za*, not certain that this nymph belongs to *S. wallworki*.

Sphaerochthonius splendidus (Berlese)

(Fig. 30)

Hypochthonius splendidus Berlese, 1904: 26, fig. 37.
Sphaerochthonius splendidus (Berlese): van der Hammen, 1959: 25.

Adult

Length, 237.5 (1). Hysteronotum light brown, proteronotum mid-brown. Cuticle covered by granulated hyaline adhesive layer. On soma, network of lines (with granules clustered around) encloses 5-sided or 6-sided areas. Granules also clustered around notal setae. Refractile parts (external malae, cheliceral extremities, setae and claws) paler than general integument.

Single specimen illustrated (Fig. 30), slightly squashed by coverslip, but natural body-form laterally compressed like *Phthiracarus* (Holonotina) or *Protoplophora* (this subcohort). Anterior 2 pairs of legs curl up under edges of proteronotum whilst posterior 2 pairs of legs curl up under flaps from pleural shields. Adanal shields may be capable of closing over anal shields. No evidence confirming acutely hinged prehysteronotal fissure, but soma looks capable of folding so that cowl covers genital shield. Anterior transverse hysteronotal fissure (*TB*1) also appears hinged. By squashing mite, second hysteronotal shield (*NS*2—narrow band bearing setae *J*2 and *Z*2) moves backwards from under anterior hysteronotal shield (*NS*1) near level of setae *J*1 and *Z*1 to be exposed at almost level of setae *J*3 and *Z*3. In illustration (Fig. 30), posterior of 4 broken transverse lines appears to represent posterior edge of folded

hyaline membrane between venter of first hysteronotal shield (*NS*1) and anterior edge of second hysteronotal shield (*NS*2). Reticulate hyaline adhesive layer passes unbroken across anterior transverse hysteronotal fissure so that any movement of shields could mean rupturing this layer.

Legs difficult to observe because folded up. Trochanter and femur III and IV similar to *Cosmochthonius*. Pretarsus IV with 3 claws (stout central claw, 2 slim lateral claws). Adanal setae *Za* and hysteronotal setae *J*6, *Z*6 and *S*6 similar to *J*4. File *Za* includes 4 setae. Single, dense granular bolus present, but no eggs observed inside specimen.

Material examined: One adult (N1979385), grass and moss or litter under *Eucalyptus viminalis*, savannah woodland, Chambers Gully, 12.6.1974, D. C. Lee.

Distribution: Mediterranean-type climate: Italy, Greece (Pm); South Australia (Aa). South Australia: Chambers Gully, savannah woodland, 1 (1/8).

Remarks: The specimen from South Australia, although much smaller than the type (310), can be grouped in *S. splendidus*. Because I have not wished to damage the single specimen, the description is unusually limited. Earlier work on the hysterosomal shields of the adult (Grandjean 1932a) and larva (Grandjean 1934) of a *Sphaerochthonius* species, indicating a hinged first transverse hysteronotal fissure that is folded forward under the anterior shield, is confirmed, which clarifies some of the confusion about hysteronotal fissures resulting from more recent descriptions of *Sphaerochthonius*. Furthermore, the presence or absence of small simple setae in the second hysteronotal rank as attributes to distinguish species can now be seen as resulting from these setae sometimes being hidden. Unfortunately, I have not established whether or not the transverse prehysteronotal fissure is acutely hinged or not. If the proteronotum can be folded right down, distinguishing the Cosmochthonioidea from the Protoplophoroidea may not be tenable.

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POLYCLAD TURBELLARIANS FROM THE SOUTHERN COASTS OF AUSTRALIA

by

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ABSTRACT

PRUDHOE, S. 1981. Polyclad turbellarians from the southern coasts of Australia. *Rec. S. Aust. Mus.* **18** (16): 361-384.

Eighteen species of polyclad turbellarians are recorded from the southern coasts of Australia, 14 of which are from South Australia and 4 from Victoria. Of the South Australian species, 2 are also recorded from Tasmania, and 1 of the Victorian species has been recorded hitherto only from South Australia. Of the species dealt with, 3 are regarded as new to polyclad systematics, and these are: *Notoplana distincta* sp.nov., and *Pseudoceros lividus* sp.nov., from South Australia and *Candimboides cuneiformis* gen. et sp.nov. from Victoria. The genus *Ancoratheca* is diagnosed. The descriptions are extended for the following 5 species: *Ancoratheca australiensis, Notoplana longicrumena, Planocera edmondsi, Cestoplana meridionalis* and *Cycloporus australis*. Three known species, *Euplana gracilis, Echinoplana tenerrima* and *Pseudoceros reticulatus* show very wide gaps in their geographical distribution, suggesting that polyclads may be artificially transported from one part of the world to another, where they may settle, if conditions are suitable.

INTRODUCTION

Background, Methods and Acknowledgements

The following report is based chiefly on a collection of polyclad turbellarians housed in the South Australian Museum, and for the pleasure of studying this material the writer is indebted to Mr David C. Lee and Mr Ifor M. Thomas. Grateful acknowledgement is made to Dr S. J. Edmonds, formerly the University of Adelaide, Mr S. A. Shepherd of the Department of Fisheries, Adelaide, Dr G. C. B. Poore of the Ministry of Conservation, Melbourne, and Mr Neville Coleman of the Marine Photographic Index, Caringbah, N.S.W., for sending specimens to the writer at different times during the past 25 years.

Little has been published on polyclads of the coasts of South Australia and Victoria and it is therefore not surprising that of the 18 dealt with here only *Notoplana australis* (Schmarda) and *Hoploplana rosea* Prudhoe have been recorded previously from these coasts. Fourteen species are here recorded from South Australia for the first time, and of these 7 are new. Of the known species, 5 have been recorded from the vicinity of Port Jackson, N.S.W., 2 from the coast of Victoria, and 1, *Thysanozoon skottsbergi* Bock, from the coast of Western Australia. Of the 4 species now recorded from Victoria, only 1 has been recorded from other Australian coasts, but whether or not this relationship denotes any zoogeographical significance requires further investigation of the polyclad fauna of Victoria, especially as Bennett and Pope (1960) indicate the Victorian coast as a cold-temperature zone situated between 2 warm-temperate regions. Hitherto, only 2 species of polyclads have been recorded from Tasmania, namely, *Notoplana australis* and *Microcelis schauinslandi* Plehn, but the number is now increased to 4 with the records of *Planocera edmondsi* Prudhoe, and *Pseudoceros reticulatus* Yeri and Kaburaki.

The present study and a review of the literature, suggest that *Notoplana australis* is probably the commonest species of polyclad inhabiting the southern and south-eastern coasts of Australia. Moreover, the species has also been recorded from New Zealand and Chile.

The occurrence of *Euplana gracilis, Echinoplana tenerrima* and *Pseudoceros reticulatus*, inhabitants of other regions of the oceans, in the present collections reveals an important problem in the study of the geographical distribution of polyclad turbellarians, for it now seems that some species are or have been transported artificially by some means or other from their endemic areas to very distant localities offering suitable habitats. This observation gives some credence to Laidlaw's (1904) record of the north-eastern Atlantic boreal polyclad *Cryptocelides loveni* Bergendal occurring in Port Phillip Bay, Victoria—the authenticity of this record has always been doubted by subsequent writers, even by Laidlaw himself.

The examination of the above-mentioned material has been carried out on whole specimens cleared in methyl salicylate and on longitudinal serial-sections of copulatory complexes cut at 10 μm and double-stained with haemalum and eosin. For the preparation of the serial sections, the writer would like to thank Mr D. W. Cooper of the Histology Section of the British Museum (Natural History).

Deposition is in the Australian Museum, Sydney, Australia (AM); British Museum (Natural History), London, England (BM); National Museum of Victoria, Melbourne, Australia (NMV); and South Australian Museum, Adelaide, Australia (SAM).

List of Species

From South Australia

Discocelis australis Hyman
Enterogonia orbicularis (Schmarda)
Ancoratheca australiensis Prudhoe
Notoplana australis (Schmarda)
Notoplana longicrumena Prudhoe
Planocera edmondsi Prudhoe
Echinoplana tenerrima Haswell
Cestoplana meridionalis Prudhoe
Pseudoceros reticulatus Yeri and Kaburaki
Pseudoceros lividus sp.nov.
Notoplana distincta sp.nov.
Tripylocelis typica Haswell
Thysanozoon skottsbergi Bock
Cycloporus australis Prudhoe

From Victoria

Latocestus sp.innom.
Euplana gracilis (Girard)
Candimboides cuneiformis gen. et sp.nov.
Hoploplana rosea Prudhoe

From Tasmania

Planocera edmondsi Prudhoe
Pseudoceros reticulatus Yeri and Kaburaki

SYSTEMATICS

Family DISCOCELIDIDAE Laidlaw, 1903, emended Poche, 1926

Discocelis australis Hyman, 1959

Locality: South Australia—one specimen (accidently destroyed) under rocks, West Is., S.A., Shepherd, 29.v.73.

Morphology: Broadly oval in outline, firm consistency, about 18 mm long and about 12 mm maximum width, which occurs in cephalic region. Ground colour greyish white with tinge of brown along median line on the dorsal surface. Surface also bears many scattered dark brown spots, so evident in most species of *Discocelis* Ehrenberg. Cerebral organ situated at about 4 mm from anterior margin of the body and near anterior end of pharynx. Eyes in region of cerebral organ, arranged more or less in two elongate clusters representing cerebral eyes. Tentacular eyes lie more dorsally than cerebral eyes and disposed in two rounded groups, laterally to cerebral eye-clusters. Numerous very small anterior marginal eyes distributed in two or three irregular rows which extend posteriorly to level of tentacular eyes. Distribution of eyes precisely as figured by Hyman (1959). Mouth opens into posterior region of the pharyngeal chamber, at about 7 mm from hinder margin of body; common genital pore about 3 mm posterior to mouth.

As seen in the whole specimen cleared in methyl salicylate, the copulatory complexes, although not fully developed, closely resemble those described and figured by Hyman for *Discocelis australis*, originally collected at Long Reef, near Sydney, N.S.W.

Family LATOCESTIDAE Laidlaw, 1903

Latocestus sp.innom.

Locality: Victoria—one fragmentary juvenile specimen (NMV/G3292), Crib Point Benthic Survey; Stn. 41 N/5, Westernport, date unknown.

Morphology: Elongate, about 5 mm long, brownish dorsally and ventrally. Eyes spread fanwise over cephalic region and marginal eyes form complete series round body.

Remarks: The genus *Latocestus* Plehn has not been recorded hitherto from Australia, but it is widely distributed in the tropical and temperate regions of the Atlantic and Indo-Pacific Oceans. Of those species recorded from the Indo-Pacific region, the present form bears some resemblance to *L. argus* Laidlaw and *L. maldivensis* (Laidlaw) in the coloration of the body and in the distribution of the eyes.

Family STYLOCHIDAE Stimpson, 1857

Enterogonia Haswell, 1907

Diagnosis: Stylochidae with rudimentary tentacles. Marginal eyes in complete series around body; cerebral eyes merge with frontal eyes to spread fanwise anteriorly and join with marginal eyes; tentacular eyes located nearer dorsal surface than cerebro-frontal eyes. Genital pores well separated. Pair of vasa deferentia unite to form ejaculatory duct; no seminal vesicle. Prostatic organ very small and "free". Penis-papilla thick, unarmed. Vagina long, forming anteriorly-directed loop from female antrum. Vagina terminating in genito-intestinal canal.

Type-species: *E. orbicularis* (Schmarda, 1859) Stummer-Traunfels, 1933.

Type-locality: although originally recorded from the Chilean coast, Stummer-Traunfels states that there is evidence that Schmarda's specimens were collected in New Zealand.

Remarks: The diagnosis of *Enterogonia* by Hyman (1959) is modified mainly because of a reinterpretation of the structure of the reproductive system (see morphology of *E. orbicularis*).

Enterogonia orbicularis (Schmarda, 1859)

Synonymy: Polycelis orbicularis Schmarda, 1859; *Enterogonia pigrans* Haswell, 1907; *Enterogonia pigrans* var. *novaezealandiae* Bock, 1925; *Enterogonia orbicularis* Stummer-Traunfels, 1933; *Enterogonia pigrans* Hyman, 1959; *Enterogonia orbicularis orbi-*

cularis Hyman, 1959; *Enterogonia orbicularis pigrans* Hyman, 1959.

Diagnosis: Fleshy forms, oval or elliptical in outline, varying from 10-34 mm long and 5-23 mm wide. Dorsal surface greenish, pale olive-green, dark grey or light brown, often with numerous greenish brown, dark olive or brownish spots. Nuchal tentacles scarcely noticeable. Anteriorly-extending cerebral eyes commence behind cerebral organ. Mouth situated centrally; elongate pharynx in middle third of body, with 10-12 pairs of lateral folds. Long, narrow, ejaculatory duct opening into narrow male antrum through unarmed penis-papilla. Epithelial lining of "shell"-chamber thrown into a spiral fold.

Localities: South Australia—2 specimens (SAM/V2631-V2637 consisting of uncut portions and serial sections), shore line, Ceduna, B. L. Baker, Nov. 1940; 1 specimen (SAM/V2625-V2630 consisting of an uncut portion and serial sections), Whittlebee Point, W. Zeidler, 2.iii.75; specimens (BM/1980.5.1.25), under stones, upper tidal zone, Port Noarlunga, St Vincent Gulf, S. J. Edmonds, 24.x.53 and on Aldinga Reef, St Vincent Gulf, S.A. Shepherd, 2.ix.72; specimens (BM/1980.5.1.29), Japanese oysters, Coffin Bay, near Port Lincoln, S.A. Shepherd, date unknown; specimen (BM/1980.5.1.30), south side of Salt Creek, Tumby Bay, Spencer Gulf, S. J. Edmonds, date unknown.

Morphology: The above specimens from South Australia, measuring 9-22 mm in length, possess a very small "free" prostatic organ and agree exactly with that described by Bock (1925) and Stummer-Traunfels (1933) in the New Zealand material. This organ may be interpreted as a small swelling arising from the dorsal wall of the ejaculatory duct, where the duct turns ventrally to enter the penis-papilla. It is lined with a glandular epithelium provided with long cilia and coated with a musculature distinctly thicker than that in the wall of the ejaculatory duct. Neither Haswell (1907) nor Hyman (1959) appear to have recognized this organ in specimens from N.S.W. Hyman (Fig. 18) depicts a dilation of the ejaculatory duct and a thickening of its muscular wall ("a curved chamber") immediately before the duct turns ventrally, and it seems possible that she mistook the insignificant prostatic organ merely as a swelling of the ejaculatory duct. Moreover, in the present material, where the prostatic organ opens into the ejaculatory duct, the latter is provided with a relatively thick musculature and further suggests that the male complex in the material examined by Haswell and Hyman might not have been fully developed.

Remarks: These worms appear to associate with colonies of bivalve molluscs, but there is no direct evidence that they are predatory on the colonies, even though they undoubtedly scavenge among them by feeding on dead or injured animals. *E. orbicularis* seems to be one of the better known Australian polyclads, for Haswell (1907) and Hyman (1959) described it from N.S.W. under the name *Enterogonia pigrans,* and Bock (1925) described specimens from New Zealand and considered them to be so very closely related to Haswell's form that he gave them the name *Enterogonia pigrans* var. *novaezealandiae.* Stummer-Traunfels (1933) redescribed Schmarda's (1859) original material of *Polycelis orbicularis* from New Zealand and considered it to be identical with *E. pigrans* var. *novaezealandiae* Bock. The main differences between the specimens from New Zealand and those from Australia are found in the greater size (26-34 mm in length of the former and 10-15 mm in the latter) and the supposed absence of a prostatic organ in the latter. In addition to these features, Hyman (1959) stated that the New Zealand form differed from the Australian one in its less roomy male antrum, in the larger penis-papilla, and in the lack of an expanded lumen in the distal region of the vagina. Bock (1925) rightly discounts the difference in size as a specific character. Concerning the differences listed by Hyman, with the exception of the prostatic organ, they are merely variations influenced to a more or less degree by size and may be considered as superficial and of no diagnostic importance.

ANCORATHECA Prudhoe, 1982

Diagnosis: Stylochidae with oval body. From anterior end of pharynx, cerebro-frontal eyes spread fanwise over cephalic region; tentacular eyes in two small groups among cerebro-frontal eyes; marginal eyes variably distributed. Genital pores adjacent. Accessory and true seminal vesicles together forming trilobed or anchor-shaped structure; prostatic organ muscular, elongate, with narrow lumen and smooth epithelial lining; penis-papilla bearing short stylet, lying in penis-pocket opening into male antrum through shallow penis-sheath. Vagina simple, terminating in Lang's vesicle sometimes opening on ventral surface of body.

Type-species: *Ancoratheca australiensis* Prudhoe, 1982

Other species: *A. pacifica* (Bock, 1923).

Remarks: The single specimen of *A. australiensis* described below is grouped in the Stylochidae because of the distribution of the eyes, the long pharynx and the posterior positions of the copulatory complexes. It bears a strong resemblance to *Neostylochus pacificus* Bock 1923, from Juan Fernandez Is. off the coast of Chile. This similarity with *N. pacificus* seems to indicate that the latter is not congeneric with the type species of *Neostylochus (N. fulvopunctatus* Yeri and Kaburaki 1918) from Japan. For instance, *N. fulvopunctatus* possesses a simple, elongate seminal vesicle and a vagina bulbosa, whereas *N. pacificus*

and *A. australiensis* have a trilobed seminal vesicle and no vagina bulbosa, differences which are here regarded as generically important. Therefore, the latter 2 species are grouped in *Ancoratheca*.

Ancoratheca australiensis Prudhoe, 1982

(Fig. 1)

Locality: South Australia—holotype (SAM/V2608-V2612, consisting of an uncut portion and serial sections), 15 metres deep, Upper Spencer Gulf, S.A. Shepherd, 5.ix.73.

Morphology: Fleshy, somewhat oval in outline, rounded anteriorly, tapering posteriorly, and of firm consistency. About 10 mm long and up to 6 mm wide. Dorsal surface of body (when preserved in alcohol) buff-coloured, dappled with dark spots, due to underlying gonads, except anteriorly and marginally, where body is somewhat lighter in colour. No tentacles. Very small marginal eyes disposed in three to five irregular rows and confined to about anterior third of total length of body. Cerebral organ somewhat bilobed. At about 3.5 mm from anterior margin, further minute eyes spread fanwise over the cephalic region to merge with marginal eyes and may be regarded as cerebro-frontal eyes. Among these, a short distance anteriorly to the cerebral organ, there is a cluster of a few eyes on either side of the median line. These are nearer to dorsal surface of the body and may be regarded as small clusters of tentacular eyes.

Pharynx narrow, about 6 mm long, mainly in posterior half of body; shows no lateral folds, only a slight rippling of lateral margins. Mouth opens into hinder region of pharyngeal chamber. Numerous intestinal branches extend to the periphery of body and do not appear to anastomose.

Genital pores very close together and appear to open into a short narrow genital atrium or a depression in the body-wall, lying at about 2.5 mm from posterior margin of the body. Near posterior end of the pharynx, the vasa deferentia become exceedingly muscular and form a pair of elongate accessory seminal vesicles which are directed postero-dorsally above 'genital atrium.' These open directly into a muscular seminal vesicle directed antero-ventrally, parallel with, and to left side of, accessory vesicles. Prostatic organ elongate and lies parallel with, and close to right side of, accessory seminal vesicles. It is invested with very thick musculature consisting of an outer layer of circular fibres and a doubly thick inner layer of longitudinal fibres. Through these layers the efferent ducts of extracapsular gland-cells pass to open into narrow lumen of prostatic organ. Latter lined with a shallow glandular epithelium, which shows no radial or longitudinal folding. Short muscular ejaculatory duct extends from seminal vesicle uniting with a muscular prostatic duct and enters very small muscular penis-papilla, armed with a short stylet. This lies in a small penis-pocket, which opens into a small antrum masculinum through a shallow penis-sheath.

Female antrum short and narrow, leading into a relatively wide vagina lined with an exceptionally tall ciliated epithelium. Numerous 'shell'-glands open into a short portion of distal half of vagina to form a 'shell' chamber, epithelium of which appears to be thrown into four or five spiral folds. From 'shell'-chamber, vagina extends posteriorly for a short distance to receive short common duct of uterine canals. From this union, vagina interna continues posteriorly to open into a spacious arcuate Lang's vesicle through a sphincter. Inner end of vesicle narrows considerably to open to exterior through a tiny pore situated at about 0.5 mm posterior to common genital opening. The epithelium of the proximal region of the vagina interna is thrown into radial folds, a feature commonly associated with the 'stalk' of Lang's vesicle. Lang's vesicle is in poor histological condition but it appears as a membranous structure lined with large gland-cells containing a secretion staining weakly with eosin. An interesting feature is that it contains small packets of spermatozoa, one of which is clustered around the sphincter at the union of the vagina and the vesicle. A few individual spermatozoa are also present in the proximal region of the vagina interna suggesting that fertilization may take place in the uterine canals. Further, it might be thought that the packets of sperm had been deposited through the body-wall by hypodermic impregnation with a penial stylet of another worm, but this does not seem to be so because the wall of Lang's vesicle is fused to the tiny external aperture.

Remarks: A. australiensis may be distinguished from *A. pacifica* by the marginal eyes not completely encircling the body and by Lang's vesicle opening on the ventral surface of the body.

The fusion of the musculature of the seminal vesicle (which consists principally of circular fibres) with its accessory vesicles appears to produce a structure similar to the trilobed or tripartite seminal vesicle of the genus *Stylochus (Imogine)*. The tight clustering together of the organs of the male copulatory complex may not be normal but due to contraction of the hinder region of the body.

The opening of Lang's vesicle directly to the exterior is very interesting, because it could be regarded as the original condition of the ductus vaginalis found in several acotylean polyclads, particularly among species belonging to the family Stylochidae. Bock (1925a), however, assumes that the ductus vaginalis has been derived from the 'stalk' of Lang's vesicle, and he presents evidence to support this assumption, with particular references to *Discocoelides langi* Bergendal, where an accessory canal connects the 'stalk' directly to the antrum femininum. Whilst Bock's

assumption may be justified in some instances, it should not be overlooked that in other instances the ductus vaginalis might also have arisen solely from Lang's vesicle, which having made contact with the exterior, as in the present form, eventually lost its function solely as a receptaculum seminis and became reduced to a narrow canal for the discharge of waste reproductive materials, as well as for copulation, thus being comparable with Laurer's canal of trematodes and the vagina of cestodes.

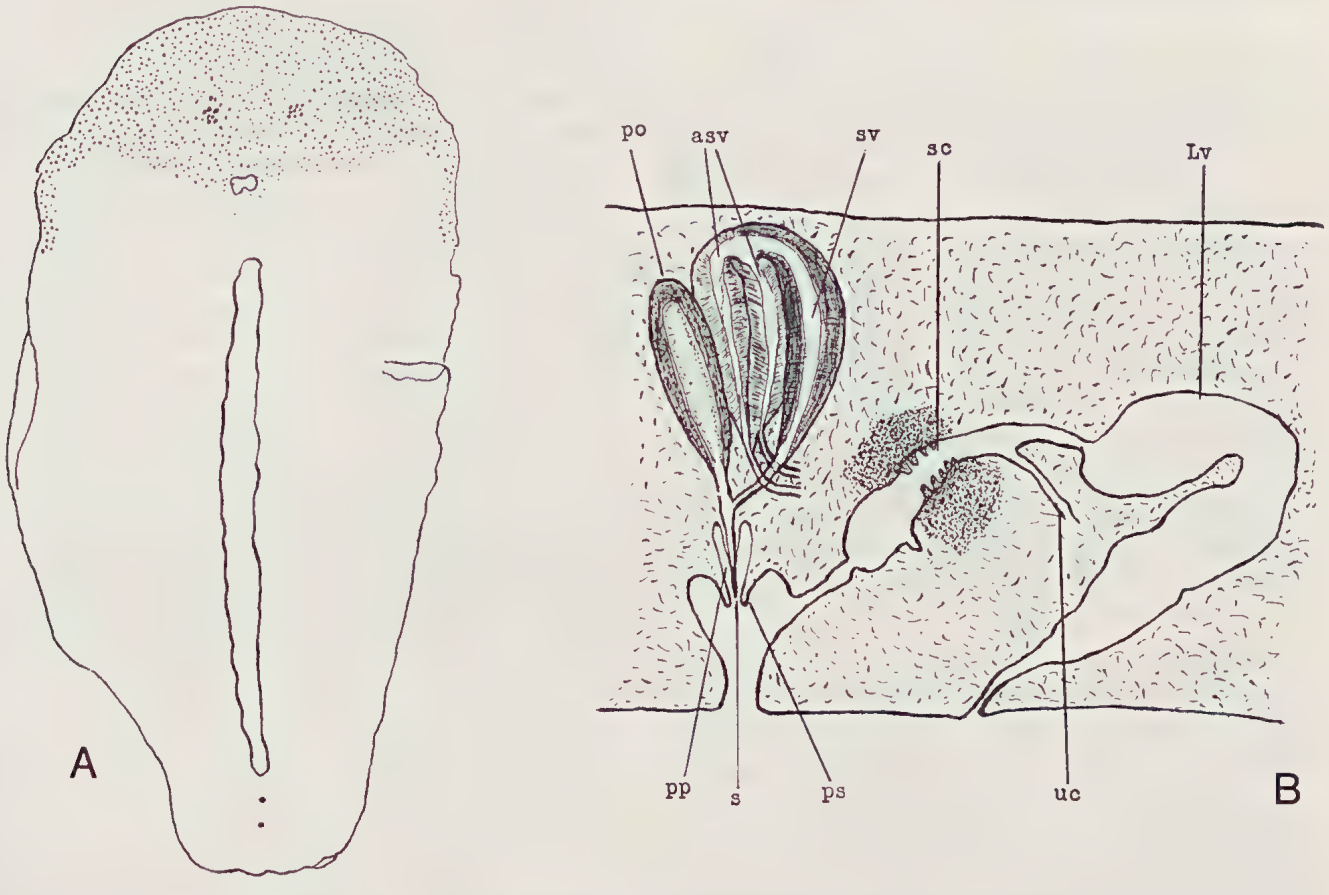

FIG.1. *Ancoratheca australiensis*. A. Dorsal view. B. Sagittal section of copulatory complexes. *asv.*, accessory seminal vesicles; *Lv.*, Lang's vesicle; *po.*, prostatic organ; *pp.*, penis-pocket; *ps.*, penis-sheath; *s.*, stylet; *sc.*, "shell"-chamber; *sv.*, seminal vesicle; *uc.*, common uterine canal

Family LEPTOPLANIDAE Ehrenberg, 1831, emended Stimpson, 1857

Euplana gracilis (Girard, 1850); Girard, 1895

(Fig. 2)

Locality: Victoria—one damaged specimen and several fragments (BM/1980.5.1.11 and NMV/G3290 and G3291), Port Phillip Bay Environmental Study; Stn. 137/3 and 137/5.

Morphology: Body delicate, elongate-oval; 3.25-5.0 mm long, 0.9-1.75 mm maximum width (measurements are estimates since no specimens complete). In alcohol, dorsal surface yellowish brown with dark brown spots from underlying ovaries; ventral surface greyish. No tentacles. Cerebral organ 0.25 mm from anterior end. Eyes few, in two rows each of 4-5 on either side of cerebral organ. Mouth opens into middle of pharyngeal chamber which lies in anterior half of body closely behind cerebral organ. Pharynx has a few pairs of shallow lateral pockets. Median intestinal trunk extends from near cerebral organ to posterior region giving off several pairs of lateral branches; these anastomose initially but are free marginally. Male and female genital pores separate and lie in middle region well behind pharynx.

Remarks: Unfortunately, the histological condition of the material does not permit of a precise examination for description, but sufficient has been made out of the reproductive system to show that it is undoubtedly comparable with that described by Hyman (1939) in American specimens.

Euplana gracilis was known hitherto to occur only on the Atlantic coast of North America, where, according to Hyman (1940), it is common in the benthic fauna of the boreal/warm temperate region and ranges from Prince Edward Island, Canada, to the western coast of Florida. Its occurrence in Port Phillip Bay is therefore surprising, and it must be assumed that the worm had somehow been transported from America, possibly when eggs attached to the

hull of a ship hatched in Victorian waters. There is also the possibility that they were carried with oysters or other animals and deposited in these waters. Bennett and Pope (1960) apparently regard the Victorian coast as a cold-temperate region, and it seems therefore to be a suitable area for *Euplana gracilis*—clearly a eurythermic species—to establish itself.

Notoplana australis (Schmarda, 1859) Bock, 1913

Synonymy: *Polycelis australis* Schmarda, 1859; *Leptoplana australis* Laidlaw, 1904; *Leptoplana suteri* Jacubowa, 1906; *Notoplana australis* forma *huina* Marcus, 1954.

Diagnosis: Body elongate oval, of variable size and coloration. Nuchal tentacles rudimentary or not apparent. Eyes of the cerebral groups smaller than the tentacular eyes. Mouth in middle region of body; pharynx with 12-17 pairs of lateral folds. Genital pores well separated. Seminal vesicle smaller than prostatic organ, which has six epithelial longitudinal chambers. Penis-papilla very small and provided with a long stylet enclosed in elongate muscular penis-pocket. Antrum masculinum narrow. Vagina bulbosa large; Lang's vesicle elongate.

Localities: South Australia—specimen (SAM/V2638-V2645—consisting of uncut portions and serial sections), near Jones Island, Baird Bay, W. Zeidler, 27.ii.75; specimen (SAM/V2646) under rocks at low tide, Daly Head, Yorke Peninsula, W. Zeidler, 9.xi.76; specimen (SAM/V2647) Brown Point, W. Zeidler, 9.viii.74; 2 specimens (SAM/V2648 and V2649), Wittelbee Point, near Ceduna, W. Zeidler, 2.iii.75; specimen (SAM/V2650) under intertidal rocks, Pondalowie Bay, W. Zeidler, 9.xi.76; specimen (BM/1980.5.1.8), Wittelbee Point, near Ceduna, W. Zeidler, 2.iii.75; specimen (BM/1980.5.1.9, in part), under rocks, upper tidal zone, American River Inlet, Kangaroo Island, S. J. Edmonds, Aug. 1946; specimen (BM/1980.5.1.9, in part) under rocks, upper tidal zone, Port Noarlunga, St. Vincent Gulf, S. J. Edmonds, November 1950; specimen (BM/1980.5.1.10), under stones, 5 metres of water, Tipara Reef, Spencer Gulf, S.A. Shepherd, 25.v.73.

Morphology: This species has been adequately described by Haswell (1907), Bock (1913) and Stummer-Traunfels (1933). It seems to be exceedingly variable in size. Existing records give the size of preserved adult worms as 19-37 mm long and 9-20 mm wide, but Haswell records specimens up to about 76 mm in length when alive. Present adult specimens are 15-32 mm long and 7-15 mm wide; one immature specimen is 20 mm long and 9 mm wide. Haswell also records small sexually mature specimens under 10 mm in length from New Zealand and suggests that they may be a dwarf variety of *N. australis*. Among the present material, a specimen from Baird Bay measures only 9 mm in length and 4 mm in maximum width, but although it has both sets of copulatory complexes there is no indication of developing ova. Marcus (1954) recorded a similar form from the coast of Chile and named it *Notoplana australis* forma *huina*, which he regarded as distinct from the dwarf form of Haswell and listed two or three morphological differences, but these appear to have no systematic importance.

The coloration of the dorsal surface of this polyclad varies greatly from almost black, through differing shades of brown, to orange; Hyman (1959) records specimens of olive-grey or greenish grey. The present adult specimens are greyish with an elongate-oval central area of pale brown; immature specimens a dull white with a tinge of brown in the pharyngeal region. The ventral surface of mature and immature worms is always somewhat lighter. The specimen from the Tipara Reef was originally orange coloured, mottled with white above and below. The dorsal surface also had a dark brown median band, due to the underlying pharynx, and the shallow nuchal tentacles were also of an orange colour with a whitish apex and a band of white about midway along each tentacle. The area around the base of each tentacle is without colour. After prolonged immersion in an alcohol preservative, this specimen has lost such coloration.

On the dorsal surface, at about the junction of the first and second quarters of the total length of the body, Haswell mentions the presence of "two clear colourless rounded knobs on which tentacular groups of eyes are borne." In the present specimens one may occasionally distinguish a pair of very shallow bosses, representing rudimentary tentacles, but in their place in other specimens there may be a pair of clear roundish areas in the region of the cerebral organ and in them lie tentacular eyes. Laidlaw (1904) and Jacubowa (1906) found rudimentary tentacles in specimens from Australia. In Chilean specimens, Marcus found rounded bosses as nuchal tentacles, which were transparent in the living animal.

The pharynx lies in the middle third of the body and possesses from 8 to 15 pairs of lateral folds. The main intestine has 12 to 15 pairs of lateral branches, which ramify towards the periphery of the body and appear to anastomose only in the pharyngeal region—a feature to be seen in other species of the genus *Notoplana* Laidlaw. In the posterior region of the pharynx, the main intestine bifurcates and the arms pass round the copulatory complexes, similarly, the anterior end of the intestine bifurcates and the limbs pass round the cerebral organ.

The structure of the copulatory complexes has been sufficiently described by Haswell (1907) and well figured by Bock (1913), Marcus (1954) and Hyman (1959) in sagittal or longitudinal section. The pros-

tatic organ in the present material agrees with that described by Laidlaw (1904) in having its epithelial lining modified into six longitudinal chambers.

Remarks: Notoplana australis is evidently a common and widely distributed species on the southern coasts of Australia. In addition to the present material from various localities on the South Australian coast, this species has been recorded from Port Phillip, Victoria, by Laidlaw (1904), from Tasmania by Haswell (1907) and from N.S.W. by Schmarda (1859), Haswell (1907), Stead (1907), Bock (1913) and by Hyman (1959). It has also been recorded from New Zealand in various localities extending from Lyttleton Harbour northwards to Auckland Harbour by Schmarda (1859), Jacubowa (1906) and by Haswell (1907). Latterly, it has been recorded from the coast of Chile between 20°S and 41°S by Marcus (1954).

Stead (1907) reported the destruction of oyster-beds by *"Leptoplana" australis* in N.S.W. While circumstantial evidence might point to this, it is more likely that some other factor was reponsible, and that the polyclads were merely engaged in cleaning up by devouring dead and injured animals. In fact, Stead speaks of the abundance of a polychaete predator and the oyster-drill *Urosalpinx* among the oysters.

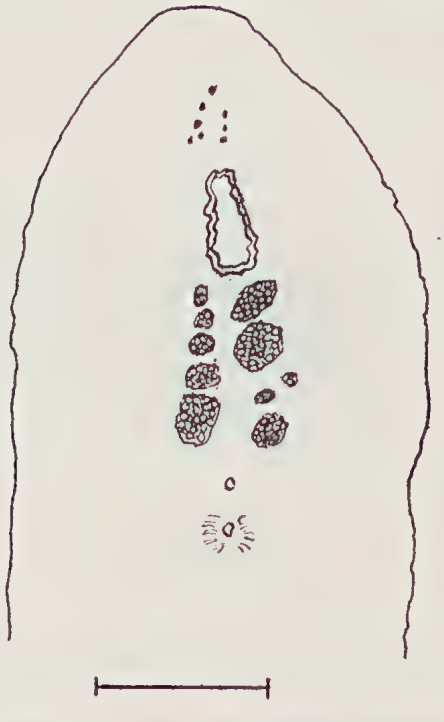

FIG. 2. *Euplana gracilis.* Anterior half of body, dorsal view (bar-scale=0.5 mm.)

Notoplana distincta sp.nov.

(Fig. 3)

Diagnosis: Body elongate oval, 21.5 mm long and pale yellowish brown. Eyes in two elongate cerebral clusters. Mouth anterior to middle of body; pharynx with 8 or 9 pairs of lateral folds. Genital pores well separated. Seminal vesicle larger than prostatic organ, which has four longitudinal epithelial chambers. Penis-papilla in the form of a long stylet entirely enclosed in penis-pocket. Antrum masculinum long and narrow, lined with tall glandular epithelium thrown into longitudinal folds. Antrum femininum narrow, lined with glandular epithelium; Lang's vesicle small and bulbous.

Locality: South Australia—holotype (BM/1980.5.1.5), under rock, upper tidal zone, Port Noarlunga, Gulf St Vincent, S. J. Edmonds, Nov. 1950.

Morphology: Rounded anteriorly and tapering posteriorly. Length, 21.5 mm; maximum width, 6 mm, which occurs in the mid-region of the body. Dorsal surface is pale yellowish brown. The cerebral organ lies at about 4 mm from the anterior margin of the body. Eyes are arranged in two elongate groups on either side of the median line in the region of the cerebral organ. There are 36 to 50 eyes in each group, and in the hinder region of each group, on the postero-lateral borders of the cerebral organ, lie 12 to 16 larger eyes more dorsally situated and represent the tentacular eyes, although tentacles are absent.

The dorsal musculature of the body-wall is, as usual in polyclads, less well developed than the ventral musculature, but the basement membrane of the dorsal wall is about twice as thick and the epithelium taller than that of the ventral wall.

The mouth lies at about 5 mm posteriorly to the cerebral organ and a little behind the middle of the pharyngeal chamber. The pharynx is situated a little anteriorly to the middle of the body and measures 3.5 mm long. It possesses 8 or 9 pairs of lateral folds. The intestinal branches appear to anastomose in the pharyngeal region and terminate trichotomously in the marginal zones of the body.

The male genital pore is situated in the central region of the body, 3.5 mm posteriorly to the mouth, and the female pore 1 mm behind the male and about 8 mm from the posterior end of the body.

The testes are scattered in the ventral parenchyma, as far as the submarginal zones of the body. The vasa deferentia arise on either side of the pharynx and extend posteriorly to a level close behind the female genital pore, where they turn inwardly to unite in the median line to form a posterior loop. About midway along their length, each vas deferens gives off a medially-directed branch, which becomes much convoluted and swollen with sperm. These two branches open independently into a muscular pyriform seminal vesicle, the narrow end of which is directed anteriorly. From the narrower end of the seminal vesicle, a short ejaculatory duct runs dorsally to lead into a globular prostatic organ provided with a relatively thick muscular wall. The ejaculatory duct passes well into the

prostatic organ and is surrounded by a tall glandular epithelium, in which there are four tubes lying parallel with the ejaculatory duct. The epithelial tubes and the ejaculatory duct open into a small chamber in the distal region of the prostatic organ. From this organ, the ejaculatory duct turns posteriorly to enter an elongate penis-papilla. The papilla is covered with a membrane or perhaps a thin cuticle and lies entirely within a penis-pocket. The proximal half of the penis-pocket encloses the papilla and is lined with a membrane or cuticle, similar to that covering the penis-papilla, whereas the distal half of the penis-pocket is lined with tall cilia. Through a shallow penis-sheath, the pocket opens into a long narrow antrum masculinum lined with a tall glandular epithelium thrown into longitudinal folds.

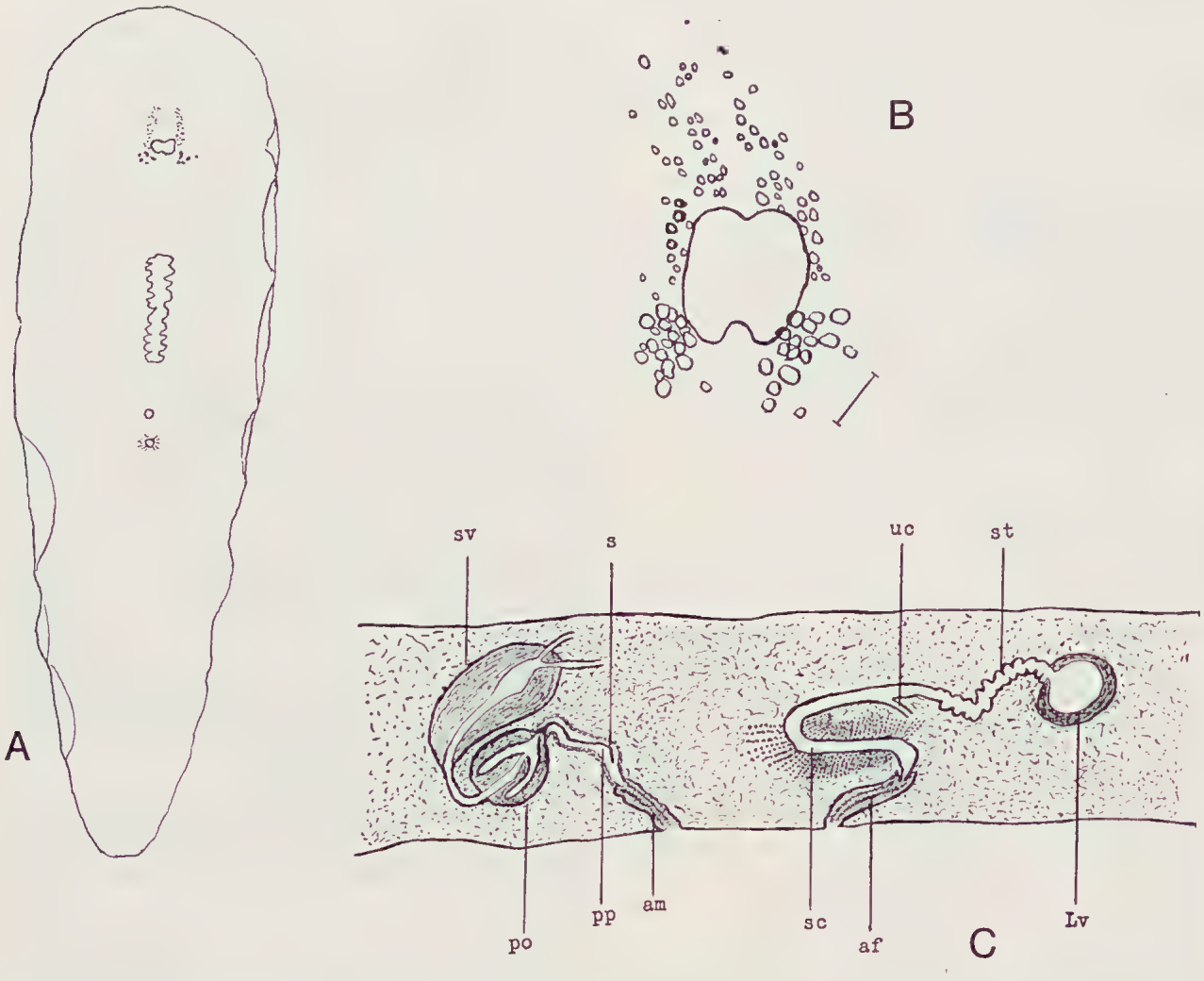

FIG. 3. *Notoplana distincta*. A. Dorsal view. B. Arrangement of eyes (bar-scale=0.2 mm.) C. Sagittal section of copulatory complexes. *af.*, antrum femininum; *am.*, antrum masculinum; *Lv.*, Lang's vesicle; *po.*, prostatic organ; *pp.*, penis-pocket; *s.*, stylet; *sc.*, "shell"-chamber; *st.*, stalk of Lang's vesicle; *sv.*, seminal vesicle; *uc.*, common uterine canal.

The dorsally-disposed ovaries are numerous and widely scattered, extending farther into the submarginal zones of the body than the testes. The uterine canal on the right side of the pharynx extends anteriorly a little beyond the pharynx, whereas that on the left side appears to be malformed, for it is thrown into several coils alongside the hinder margin of the pharynx. The posterior ends of the two uterine canals unite to form a short common duct opening into the vagina at the union of the vagina interna and the "stalk" of Lang's vesicle. The epithelium of the "stalk" is thrown into radial folds, so that the lumen appears moniliform in longitudinal section. Lang's vesicle is small and lies at a level a little posteriorly to the female genital pore. It is lined with a highly glandular epithelium and coated with a relatively thick musculature. From the uterine opening, a short vagina interna extends anteriorly to enter a narrow "shell"-chamber, which soon turns ventrally to run posteriorly to a point ventrally to the union of the uterine canals,

where it curves ventrally to open into the antrum femininum through a distinct conical papilla. The "shell"-chamber is heavily invested with "shell"-glands and lined with an epithelium bearing tall cilia. The antrum femininum is narrow and lined with a tall glandular epithelium.

Remarks: The features of this new species are the forward position of the pharynx, the wide separation of the male copulatory complex from the posterior end of the pharynx, the widely-separated genital pores in the middle third of the body and the glandular nature of the male and female antra. A further feature is the conical papilla through which the "shell"-chamber opens into the antrum femininum, but this structure is unusual among polyclads, and it needs to be confirmed as a characteristic of the species.

Notoplana longicrumena Prudhoe, 1982

(Fig. 4)

Diagnosis: Body elongate oval in outline, up to 25 mm in length; dorsal surface yellowish grey, tinged with brown along median line; ventral surface greyish. No nuchal tentacles. Eyes in two elongate groups. Mouth centrally situated; pharynx with about 9 pairs of lateral folds. Genital pores separated. Seminal vesicle more or less as large as prostatic vesicle, which has five longitudinal epithelial chambers; long penis-papilla in form of stylet projecting well into male antrum, which is narrow and deep. Antrum femininum narrow; Lang's vesicle bulbous.

Locality: South Australia—holotype (SAM/V2651—V2665—consisting of uncut portion and 14 slides of serial sections), Point Brown, W. Zeidler, 9.viii.74.

Morphology: It is elongate oval in outline, rounded at both ends and measuring 25 mm long and 10 mm wide. Its dorsal surface is yellowish grey, with a tinge of brown in the middle region, while its ventral surface is greyish. There is no indication of nuchal tentacles. The mouth is centrally placed and opens into the middle region of the pharyngeal chamber, which holds a pharynx measuring about 6 mm in length and possessing about 9 pairs of lateral folds.

Eyes are disposed in two elongate groups extending anteriorly for about 1 mm from the cerebral organ, which is situated at about 5 mm from the anterior margin of the body. The two groups of eyes tend to converge gradually as they move forward from the cerebral organ, and each group consists of cerebral and tentacular eyes, the latter being larger, nearer to the dorsal wall of the body and laterally to the cerebral organ and hinder cerebral eyes.

The dorsal epithelium of the body is higher than the ventral epithelium, and the musculature of the ventral wall is two to three times deeper than that in the dorsal wall.

The male genital pore is situated 4 mm posteriorly to the pharynx and the female pore 0.8 mm behind the male. A pair of convoluted vasa deferentia originate in the ventral parenchyma on either side of the median line, close behind the pharynx. They extend posteriorly to about level with the male genital pore, where they turn inwardly to open quite independently of each other, into the seminal vesicle. There is no indication of branches to the vasa deferentia extending posteriorly and uniting behind the vagina, as found in other species of *Notoplana*. The seminal vesicle is pyriform and possesses a well-developed musculature of circular fibres. Its narrow end is directed anteriorly. The globular prostatic organ lies dorsally to the distal end of the seminal vesicle and is thickly coated with circular and mainly longitudinal muscle fibres, investing a tall glandular epithelium. From the distal end of the seminal vesicle, a short ejaculatory duct extends dorsally to penetrate some way into the prostatic organ, the epithelium of which envelops the duct and contains five elongate compartments lying parallel with the duct. The compartments and the duct open together into a small chamber in the distal part of the prostatic organ. From the latter, the ejaculatory duct leads into a relatively long slender penis-papilla coated with a cuticle and may be regarded as a stylet, which projects into the male antrum through a long convoluted penis-pocket with no sign of a penis-sheath. The penis-pocket is lined with a ciliated epithelium coated with a thin musculature invested by a thickened parenchyma. The male antrum is deep and narrow, and lined with an epithelium continuous with that of the ventral wall of the body.

The female genital pore leads into a narrow and shallow antrum femininum or vagina externa, which extends dorsally to open into the vagina media. The inner two-thirds of the vagina media is surrounded by numerous "shell"-glands and functions as a "shell"-chamber. This chamber extends to the dorsal wall of the body, where it turns posteriorly to open into the vagina interna. This region of the vagina continues posteriorly to open into a bulbous Lang's vesicle. Shortly before opening into Lang's vesicle, the vagina receives the common duct of the two uterine canals. Anteriorly, the uterine canals are confluent in front of the pharynx. The vagina is coated with a musculature of longitudinal and circular fibres and lined with a ciliated epithelium, whereas Lang's vesicle is lined with a shallow glandular epithelium.

Remarks: Many species have been assigned to the genus *Notoplana* Laidlaw and about 10 of these have, like the present form, no tentacles, a relatively large Lang's vesicle, and a long penis-pocket enclosing a long slender penial stylet. *N. longicrumena* differs

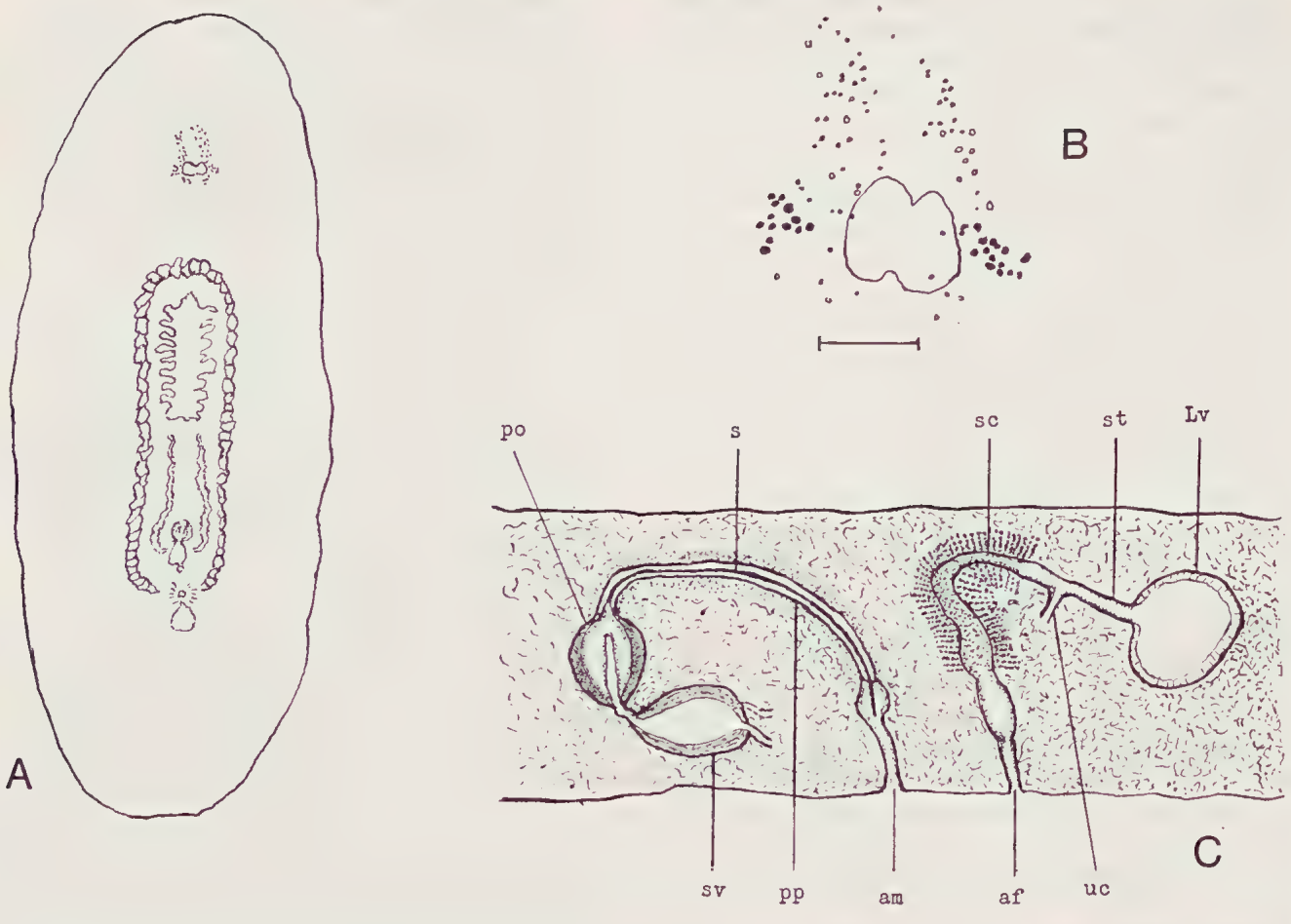

FIG. 4. *Notoplana longicrumena*. A. Dorsal view. B. Arrangement of eyes (bar-scale=0.5 mm.) C. Sagittal section of copulatory complexes. *af.*, antrum femininum; *am.*, antrum masculinum; *Lv.*, Lang's vesicle; *po.*, prostatic organ; *pp.*, penis-pocket; *s.*, stylet; *sc.*, "shell"-chamber; *st.*, stalk of Lang's vesicle; *sv.*, seminal vesicle; *uc.*, common uterine canal.

principally in the comparatively long penis-pocket, which measures about the combined length of the seminal vesicle and prostatic organ, whereas in other species the length of the penis-pocket is only as long as one or other of these organs. Of the species of *Notoplana* possessing a long slender penis-papilla covered with a thin cuticle and lying in a long penis-pocket, the present form closely resembles *N. sawayai* Marcus, 1947, from Brazil and *N. parvula* Palombi, 1924, from Indonesia. Both of these latter forms, however, possess a vagina bulbosa, which is absent in *N. longicrumena*. This species also closely resembles the foregoing *N. distincta*. It differs, however, in the arrangement of the eyes, in the position of the mouth and pharynx, in the relative length of the penial stylet and in one or two other less important features.

Tripylocelis typica Haswell, 1907

(Fig. 5)

Locality: South Australia—a mature and an immature specimen (SAM/V2667), Wittelbee Point, West Coast, W. Zeidler, 2.iii.75.

Morphology: The mature specimen is elongate oval and measures 12 mm long by 5 mm wide. Dorsally, the body is light brown, ramified with a darker colouration, due to the dark green lining of the gut branches, but in the immature specimen the greenish ramification is apparent only in the pharyngeal region. The ventral surface is of a lighter colour.

A pair of nuchal tentacles occurs at about 1.5 mm from the anterior extremity of the body. About 15 eyes lie on one tentacle and about 19 in the other. The cerebral organ lies in the median line, between the tentacles, and around it cerebral eyes are arranged in two groups.

The mouth is situated in the middle region of the body. The pharynx is about 4 mm long and lies in the middle third of the body. It possesses 9 to 10 pairs of lateral folds. The intestinal trunk is about as long as the pharynx and has 9 or 10 pairs of lateral limbs, which branch towards the margins of the body and do not anastomose. The trunk bifurcates anteriorly and posteriorly.

The male pore is situated at 3.5 mm from the posterior margin of the body, and the female pore about 1 mm behind the male. As is usual among polyclads, the testes and ovaries are disposed ventrally and dorsally, respectively. The vasa deferentia appear

on either side of the pharynx in the region of the mouth and proceed posteriorly in the ventral parenchyma to a little beyond the level of the hinder end of the pharynx, where they turn inwardly to meet in the median line and lead into a short convoluted ejaculatory duct, directed anteriorly. The duct opens into the inner end of a small, dorso-ventrally elongate, seminal vesicle, differentiated from the ejaculatory duct by a somewhat thicker musculature. The dorsal end of the seminal vesicle narrows and bends posteriorly as the ejaculatory duct is thrown into several coils. This latter portion of the ejaculatory duct is lined with a relatively tall ciliated epithelium and has a very narrow lumen. Finally, the duct enters a well-developed unarmed penis-papilla containing numerous gland-cells, and, as noted by Haswell (1907), this suggested that the distal region of the ejaculatory duct might have a prostatic function. The penis-papilla appears as an evagination of the inner end of the long, convoluted, posteriorly directed antrum masculinum, for its epithelial covering is similar to the lining of the male antrum. This epithilium is highly glandular and bears very long cilia. Almost throughout its length, the lumen of the male antrum holds accumulations of an eosinophilous granular material, an indication that the gland cells of the epithelial lining possibly produce a prostatic substance.

The female pore leads into a short narrow antrum femininum, directed dorsally. The antrum opens into a narrow vagina media extending anteriorly to near the male antrum, where it loops dorsally and runs posteriorly to a region above the female antrum. In this region the vagina turns ventrally to receive the common duct of the 2 uterine canals. The vagina media represents that portion of the vagina extending from the female antrum to near the entrance of the common uterine duct. This portion has plicate walls lined with a ciliated epithelium, and into its lumen open the ducts of innumerable extracapsular "shell"-glands investing its entire length, and for this reason the vagina media may be regarded as a long narrow "shell"-chamber. From the latter, the vagina interna, lined with well-developed ciliated cells, continues to the point where it turns ventrally. At this point, after receiving the common uterine canal, the vagina interna gives rise to a ductus vaginalis which extends ventrally to open into the ectal region of the female antrum. The ductus vaginalis is lined with a tall ciliated epithelium, similar to that lining the vagina externa and the uterine canals. On leaving the vagina interna, the uterine canals run alongside the pharynx to near its anterior extremity, where their ends remain separated. From its union with the vagina interna, the lumen of the ductus vaginalis gradually narrows, presumably contracting to prevent the flow of eggs not covered with "shell" material, but used for the expulsion of excess reproductive materials and as a copulatory organ, corresponding to Laurer's canal in trematodes and the vagina in cestodes, as suggested by Haswell.

Remarks: The mature specimen described above agrees very well with *Tripylocelis typica* as described by Haswell (1907) from N.S.W., but differs principally in one feature, for the ductus vaginalis opens into the antrum femininum and not independently on the ventral surface of the body, as Haswell states. This difference is here not regarded as diagnostically important and the present specimen is determined as *Tripylocelis typica* Haswell, 1907. On the other hand, if it were found that the difference in the position of the opening of the ductus vaginalis was constant in specimens from South Australia and N.S.W., then this feature could be regarded as one of systematic interest. Moreover, there are differences in the structure of the male copulatory complex, but these are probably no more than varying stages of development.

CANDIMBOIDES gen.nov

Diagnosis: Leptoplanidae. Body elongate, without tentacles. Eyes in two elongate clusters in region of cerebral organ. Pharynx in middle third of body. Male and female genital pores approximate and well separated from posterior margin of body. Male copulatory complex immediately posterior to pharynx. Vasa deferentia unite to form common duct opening into muscular seminal vesicle. Prostatic organ muscular and lined with tall, smooth, glandular epithelium. Penis-stylet lying in penis-pocket. Female copulatory complex includes bursa copulatrix and Lang's vesicle.

Type-species: *C. rabita* (du B. R. Marcus & Marcus, 1968) comb.nov.

Other species: *C. cuneiformis* sp.nov.

Remarks: Two specimens of this genus are available. Although their copulatory complexes are not yet fully developed and the gonads are not yet ready to begin their reproductive processes, it is possible to recognise that they are closely related morphologically to *Candimba rabita* du B. R. Marcus and Marcus 1968 from the Caribbean island of Curacao. However, the two forms differ from one another in several features, principally in the structure of the copulatory bursa and in the relative positions of the seminal vesicle and the prostatic organ. When du B. R. Marcus and Marcus (1968) considered the species *C. rabita* to be congeneric with the type-species of *Candimba* (*C. divae* Marcus, 1949, from Brazil), they regarded the absence of a bursa copulatrix in the latter to be of no generic importance. There are however, other important features by which the two forms may be differentiated. In *C. divae* the pharynx lies in the anterior third of the body, the genital pores are widely separated, a penis-stylet and a penis-pocket are absent, whereas in *C. rabita* the pharynx lies in the middle third of the body, the genital pores are close to each other, a penis-stylet and a penis-pocket are present.

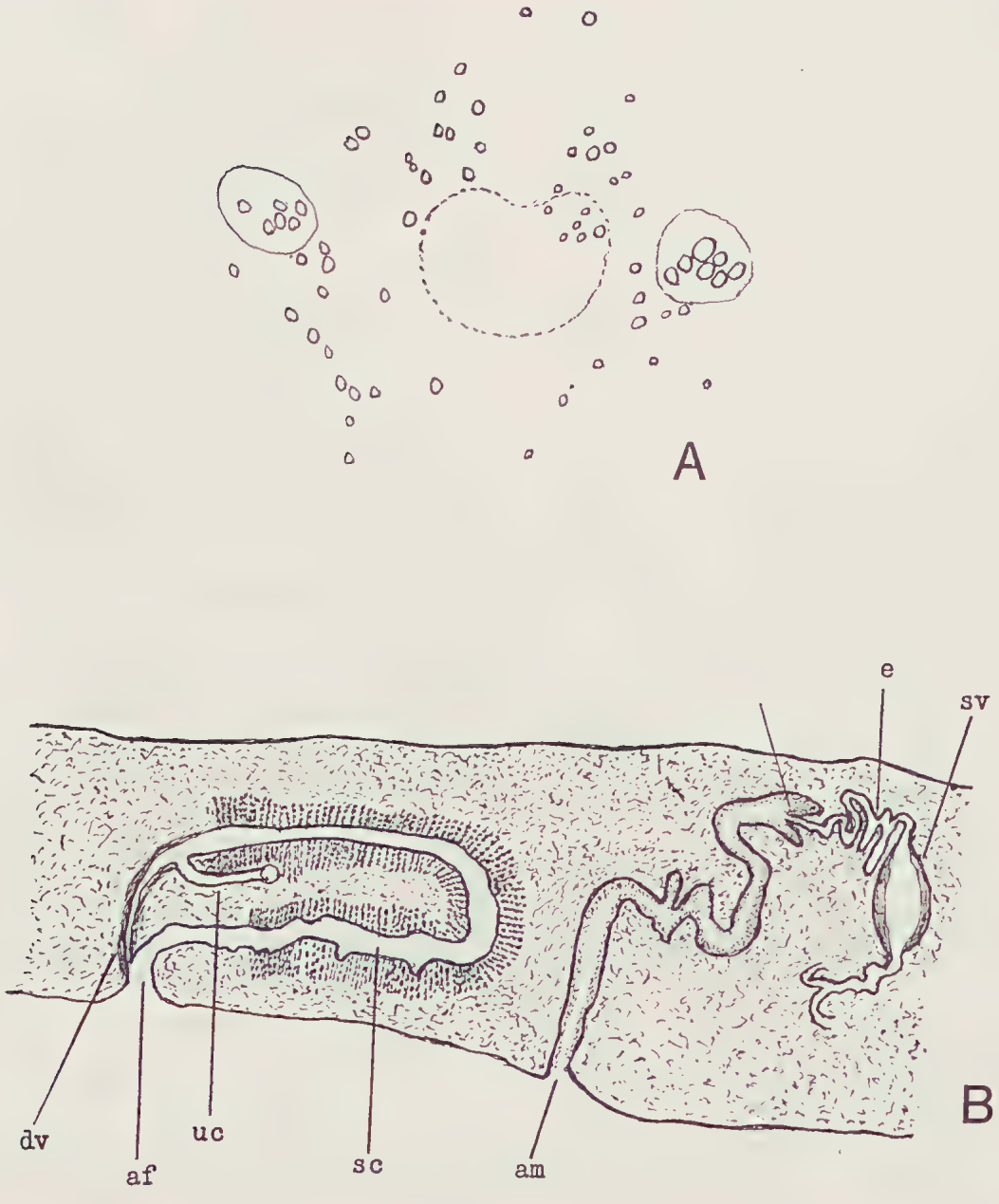

FIG. 5. *Tripylocelis typica*. A. Arrangement of eyes. B. Sagittal section of copulatory complexes. *af.*, antrum femininum; *am.*, antrum masculinum; *dv.*, ductus vaginalis; *e.*, ejaculatory duct; *p.*, penis-papilla; *sc.*, "shell"-chamber; *sv.*, seminal vesticle; *uc.*, common uterine canal.

C. cuneiformis agrees with *C. rabita* in all of these features, and they are both dissimilar from *Candimba divae*, which is the reason for establishing *Candimboides*.

Candimboides cuneiformis sp.nov.

(Fig. 6)

Localities: Victoria—holotype (NMV/G3294), sample M7/1-3, Westernport Bay Environmental Study, Jan., 1974; paratype (BM/1980-5.1.15), sample 32N, Crib Point Benthic Survey, Aug. 1966.

Morphology: The specimen from Westernport Bay is rather distorted and slightly macerated, and that from Crib Point is also in poor histological condition, but apparently both have a somewhat cuneiform outline, rounded anteriorly and tapering posteriorly, and measure about 6.5 mm long and about 2.5 mm wide. Dorsally, the body is brownish, speckled with dark spots, due to underlying ovaries, which are widely scattered, leaving only the marginal regions free.

The cerebral organ is situated at 1 mm from the anterior margin of the body and bounded by an elongate cluster of eyes on either side. The clusters are short and tend to converge anteriorly. In the specimen from Crib Point there are about 40 eyes in each cluster, whereas in the younger worm from Westernport Bay there are only about 20 eyes in each cluster.

The mouth is situated at about 3 mm from the anterior margin of the body and opens into the middle region of the pharyngeal chamber, which is about 1.5 mm long and contains a short pharynx provided with six pairs of lateral folds. Details of the intestinal

system have not been made out, but the posterior gut branches of the younger specimen appear to be infested with many gregarines.

The hinder half of the specimen from Crib Point has been serially sectioned, and in this specimen the male genital pore is situated at 2.5 mm from the hinder margin of the body, and the female genital pore at 0.3 mm posteriorly to the male pore.

As is usual in polyclads, the testes lie in the ventral parenchyma and the ovaries in the dorsal, with a tendency for the ovaries to move ventrally and mingle with the testes. It has been difficult to make out the vasa deferentia, but they appear to arise in the pharyngeal region and run posteriorly to about the level of the male pore, where they turn inwardly to unite in the median line and form a short anteriorly directed ejaculatory duct. This duct opens into the posterior end of an oval seminal vesicle lying close to the dorsal wall of the body and directed obliquely ventrally. The vesicle is very muscular, its wall consisting of a relatively thick layer of longitudinal and circular fibres. Presumably, the male copulatory complex is not yet fully functional, because the seminal vesicle contains no sperm, but an eosinophilous material similar to that found in the prostatic organ and had probably been forced into the vesicle by contraction of the body at fixation. The anterior end of the seminal vesicle narrows to open into an ejaculatory duct, which curves posteriorly and ventrally to open into the anterior end of the prostatic organ through a shallow papilla. The prostatic organ is oval and lies ventrally to the seminal vesicle, which is of similar size. It is invested with a thick layer of mainly longitudinal muscles, but the portion of the ejaculatory duct passing through the wall of the prostrate is enveloped by a layer of circular muscles, probably functioning as a sphincter. The prostatic organ is lined with a tall, vacuolate, glandular epithelium which produces a granular material. The posterior end of the prostatic organ opens directly into a long slender penis-papilla, the distal two-thirds of which, about 0.35 mm long, is covered with a thick cuticle and may be regarded as a penis-stylet. This stylet appears to be slightly flattened dorso-ventrally to produce an unusual shape, as illustrated (Fig. 6B). It lies in a penis-pocket that opens into a narrow male antrum through a shallow penis-sheath.

The ovaries are widely distributed, extending from level with the eyes to the posterior region of the body. The female pore leads into a narrow antrum. Through the anterior wall of the antrum, near its external aperture, opens a relatively large bursa copulatrix. This bursa is directed dorsally and lies to one side of the median line. The efferent canal of the bursa is exceedingly narrow and invested with compact parenchymatous tissue. Dorsally, it opens into a swollen muscular structure lying above the male pore. In the present specimen there appears to be little or no lumen to the bursa, until it opens into its bulbous portion, which is provided with a thick muscular wall and lined with a tall ciliated epithelium. From the opening of the bursa copulatrix into the antrum femininum, the vagina extends to near the dorsal wall of the body, where it turns posteriorly and curves ventrally to receive the common duct of the uterine canals. From this union, the vagina continues ventrally to open into a small globular Lang's vesicle. "Shell"-glands are not yet developed, hence a "shell"-chamber is not yet apparent.

Family HOPLOPLANIDAE Stummer-Traunfels, 1933

Hoploplana rosea Prudhoe, 1977

Localities: Victoria—one specimen (NMV/G3293), sample 23S/5, Crib Point Benthic Survey, 1965; one specimen (BM/1980.5.1.21), sample W/1, Westernport Bay Environmental Study, 29.xi.73.

Morphology: The two specimens are discoid and have a diameter of 5-6 mm. The colour of the papillate dorsal surface of the specimen from Crib Point is brownish, instead of pinkish as in the type-specimen of the species from South Australia, while the specimen from Westernport Bay is greyish after preservation in alcohol. The morphology of both specimens appears to be identical with that of the type-specimen.

Family PLANOCERIDAE Stimpson, 1857

Planocera edmondsi Prudhoe, 1982

(Figs. 7 and 8)

Localities: South Australia—holotype (SAM/V2668), under rocks, upper tidal zone, Port Noarlunga, St Vincent Gulf, S. J. Edmonds, Nov., 1950.

Tasmania—2 paratypes (BM/1980.5.1.13-14), on *Sonderophycus* in 30 metres, Little Squally Cove, Deal Island, Bass Strait, S.A. Shepherd, 4.v.74.

Morphology: Strongly leaf-like and rounded oval in outline. The holotype measures 27 mm by 19.0 mm. Dorsal surface of the living worm reddish or reddish brown. Preserved specimens still retain patches of such pigment, particularly on tentacles. On the dorsal surface, there is a pair of conspicuous, non-retractile, nuchal tentacles lying 1.5 mm apart and situated at about the junction of the first and second thirds of the total length of the body. Between the tentacles lies the cerebral organ. At the base of each tentacle there is a ring of 40 or 50 tentacular eyes, and around the cerebral organ numerous cerebral eyes are scattered. The cerebral eyes show indistinctly a division into two lateral clusters, commonly found among species of the genus *Planocera* Blainville, and each cluster showing some indication of a division

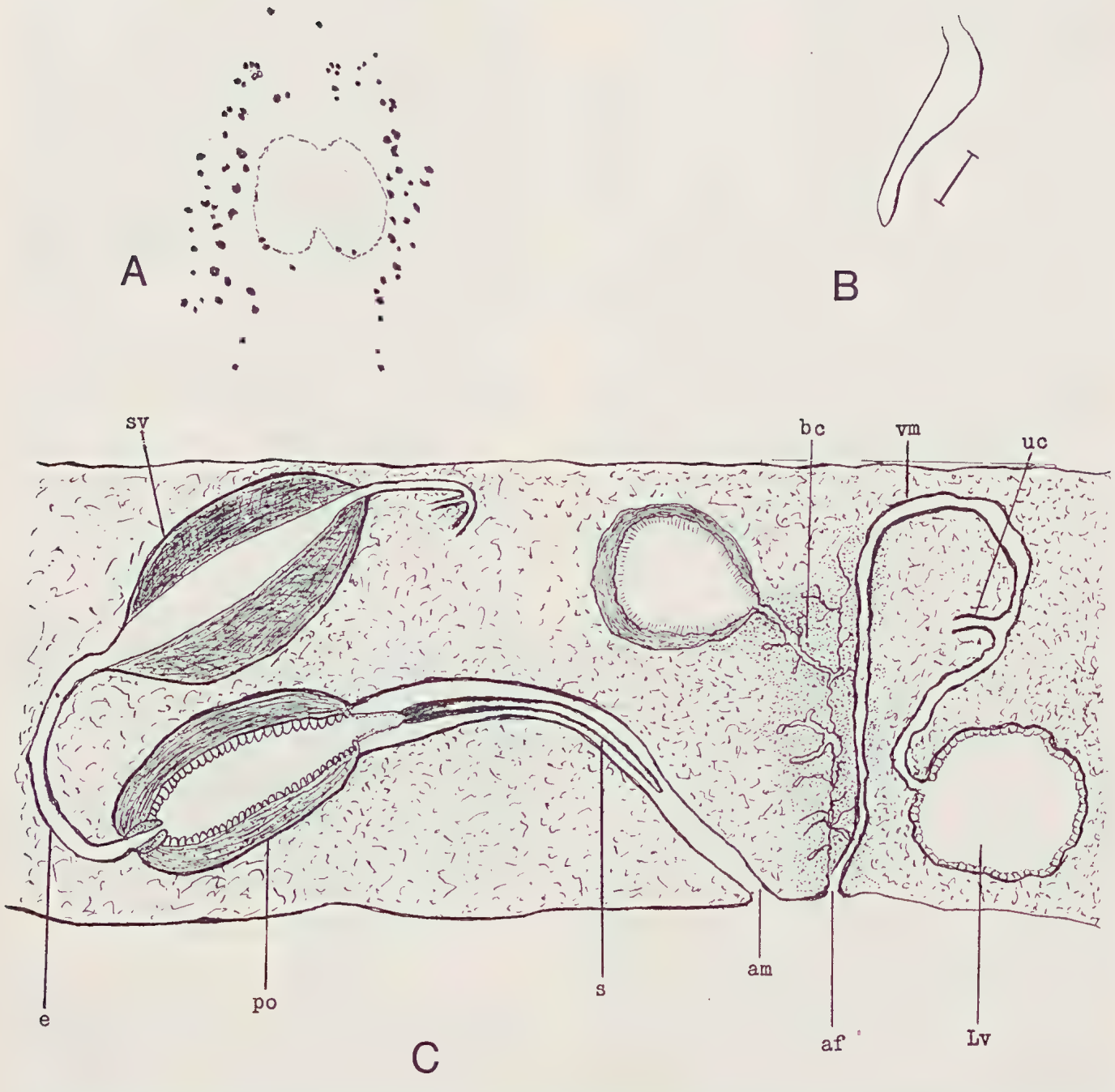

FIG 6. *Candimboides cuneiformis*. A. Arrangement of eyes; B. Penis-stylet (bar-scale=0.1 mm.) (ventral view). C. Sagittal section of copulatory complexes. *af.*, antrum femininum; *am.*, antrum masculinum; *bc.*, bursa copulatrix; *e.*, ejaculatory duct; *Lv.*, Lang's vesicle; *po.*, prostatic organ; *s.*, stylet; *sv.* seminal vesicle; *uc.*, common uterine canal; *vm.*, vagina media.

into an anterior and a posterior group in relation to the cerebral organ (Fig. 7B).

The mouth occurs in the middle region of the body, and in the largest specimen at about 5 mm behind the cerebral organ. It opens into a pharyngeal chamber, about 5 mm long, containing a well-developed pharynx possessing four pairs of deep lateral folds. The intestinal trunk is about as long as the pharyngeal chamber and has six or seven pairs of deep lateral branches and a forwardly-directed branch passing over the cerebral organ. The dendriform offshoots of the intestinal branches do not anastomose.

The male pore is situated at 3.5-4 mm posteriorly to the mouth, and the female pore 2.0-.25 mm behind the male. The male copulatory complex lies close behind the pharynx and is directed anteriorly from its ventral aperture. The testes are widely distributed, ventrally to the intestinal branches. The vasa deferentia arise on either side of the female copulatory complex, close to the ventral wall of the body, and take a convoluted course anteriorly to near a level with the hinder end of the pharynx, where they turn medially to open together into a seminal vesicle. The latter appears to be a structure of two compartments, one being vesicular and the other wholely muscular. The union of the vasa deferentia gives rise to a narrow ejaculatory duct which passes through the muscular compartment of the seminal vesicle to open into the vesicular compartment containing a mass of sperm. From the sperm-containing section, a narrow duct passes through the muscular section, skirting the pos-

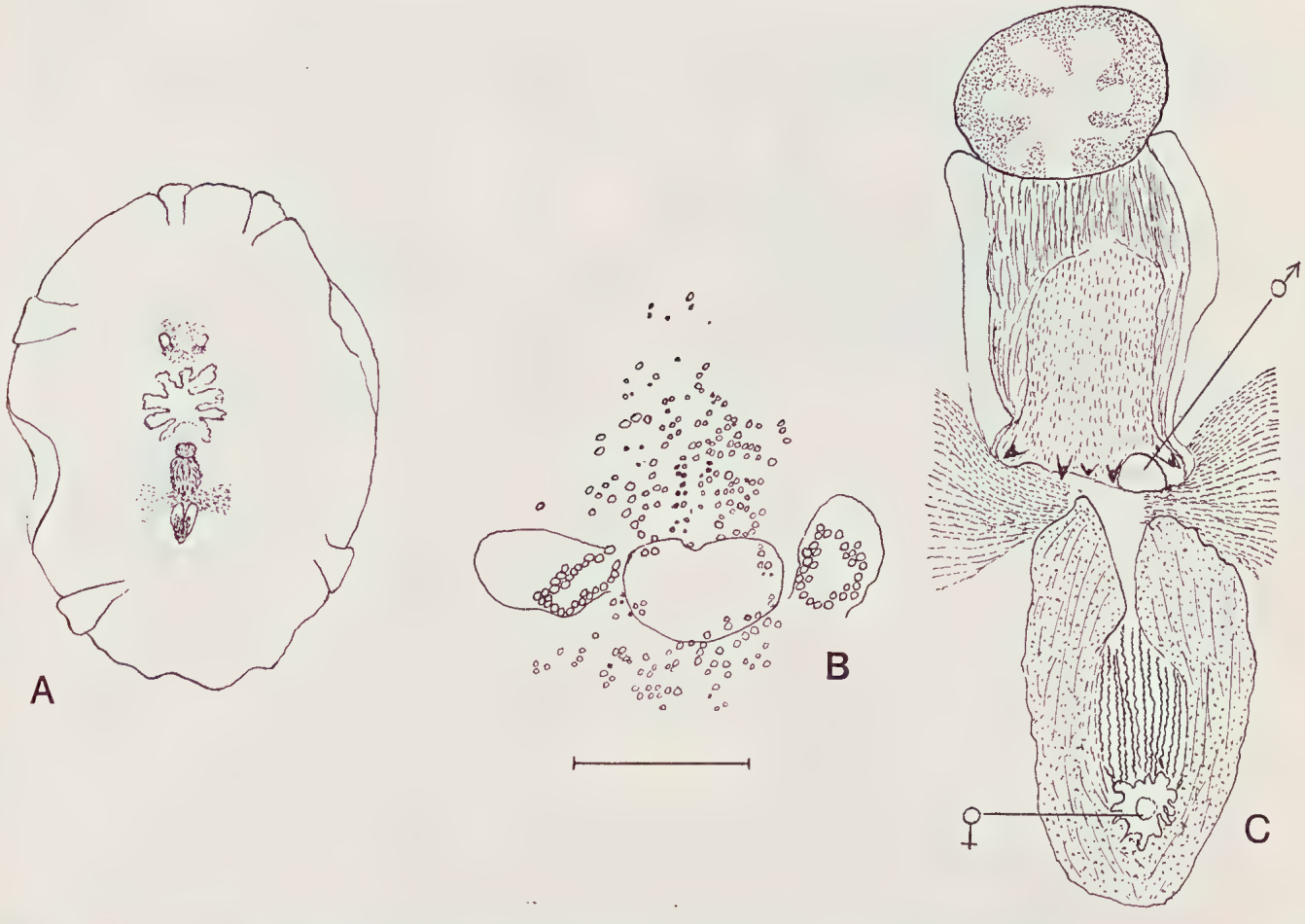

FIG 7. *Planocera edmondsi*. A. Dorsal view. B. Arrangement of eyes (bar-scale = 1 mm.) C. Copulatory complexes, with their respective apertures (ventral view).

terior and ventral walls of the prostatic organ, through a pocket surrounding the proximal region of the cirrus cavity, to unite with the prostatic duct. The prostatic organ is a globular structure lying antero-dorsally to the seminal vesicle. As in other species of *Planocera*, the prostatic organ is lined with a very tall, much-folded, glandular epithelium. The prostatic duct springs from the posterior wall of the prostatic organ and soon opens into the ejaculatory duct, which enters the anterior end of the cirrus-sac or intromittent organ through a broad projection that is probably no more than a slight eversion of the inner or proximal end of the cirrus-sac, since it is covered with spines. The cirrus-sac has a narrow lumen and is lined with strong spines that gradually increase in size towards the outer or distal end. Around the opening of the cirrus-sac, as it opens into a very shallow male antrum, there are five very large spines or teeth. The cirrus-sac and the prostatic organ are invested with a thick muscular sheath, in which there is a cavity around the proximal half of the cirrus-sac and the ejaculatory duct.

The ovaries are numerous and distributed widely in the dorsal parenchyma. The female genital pore opens directly into a large bursa copulatrix provided with an exceedingly thick musculature of circular, longitudinal and radial fibres. The bursa appears to contain three indistinct sections. The distal and proximal sections are lined with a ciliated epithelium, whereas the central section is lined with a cuticle thrown into longitudinal ridges. The bursa is directed anteriorly and leads into a wide vagina media, much of which functions as a "shell" chamber, being invested with innumerable "shell" glands. From the bursa, the vagina media makes a wide posteriorly directed curve to receive the common uterine canal. From this union, the vagina continued posteriorly as a narrow rudimentary Lang's vesicle.

Remarks: This species is named after Dr S. J. Edmonds, formerly of the University of Adelaide, and is readily differentiated from all known species of the genus *Planocera* by the unusual structure of the seminal vesicle and by the presence of five thorn-like spines embedded in the wall around the opening of the cirrus-sac.

Family GNESIOCEROTIDAE du Bois-Reymond Marcus and Marcus, 1966, emend.

Gnesiocerinae du Bois—Reymond Marcus and Marcus, 1966

Diagnosis: Planoceroidea with elongate-oval body. Eyes in two elongate clusters alongside cerebral organ, or in paired cerebral and tentacular clusters. Pharynx

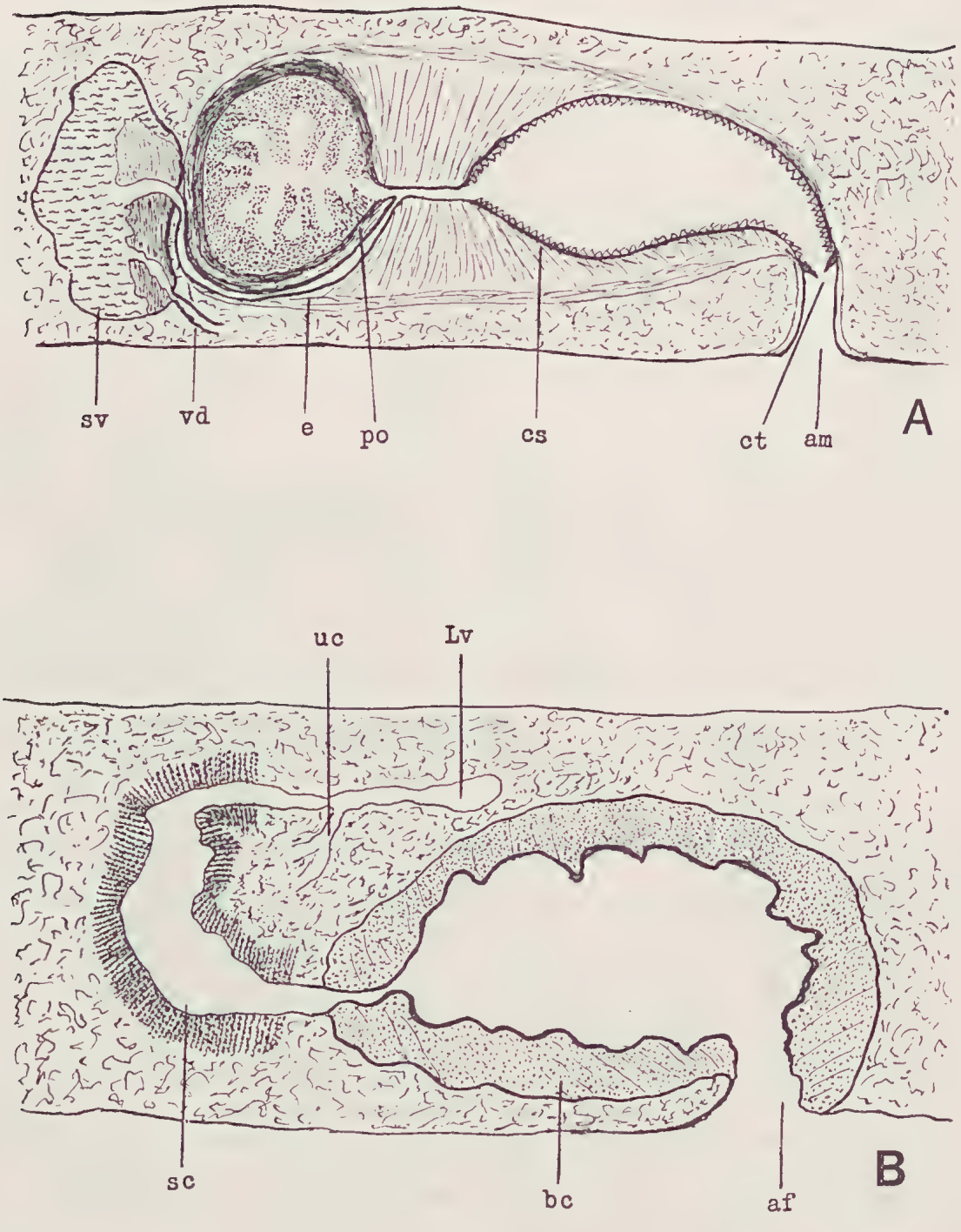

FIG. 8. *Planocera edmondsi*. A. Male copulatory complex. *am.*, antrum masculinum; *cs.*, cirrus-sac; *ct.*, cirrus-teeth; *e.*, ejaculatory duct; *po.*, prostatic organ; *sv.*, seminal vesicle; *vd.*, vas deferens; B. female copulatory complex. *af.*, antrum femininum; *bc.*, bursa copulatrix; *Lv.*, Lang's vesicle; *sc.*, "shell"-chamber; *uc.*, common uterine canal.

much folded, situated in middle region of body, or somewhat anteriorly. Genital pores separate. Vasa deferentia may form pair of accessory seminal vesicles or open into true seminal vesicle. Prostatic organ well developed, interpolated between sperm reservoir and cirrus sac. Epithelium of prostatic organ tall and thrown into folds, distal or ectal region of prostatic organ narrows to open into cirrus-sac invested with thick musculature. Cirrus-sac contains well-developed cuticularized papilla or lined with thick cuticle, often covered with stiff bristles or spines. Vagina simple, but may possess vagina bulbosa and Lang's vesicle.

Remarks: The known genera constituting this family are listed by du Bois—Reymond Marcus and Marcus (1968) under the subfamily "Gnesiocerinae". They divided the Planoceridae into two subfamilies: the Planocerinae and the Gnesiocerinae; based on the presence of an interpolated prostatic organ or of an independent or so-called "free" prostatic organ. The Gnesiocerinae is characterised by an interpolated prostatic organ, through which sperm passes during copulation, and the Planocerinae by an independent prostatic organ. The position of this organ in relation to the ejaculatory duct is of family importance among

acotylean polyclads and differentiates the family Leptoplanidae from the Callioplanidae, and the Stylochidae from the Cryptocelididae. Therefore, to be consistent in classifying acotylean polyclads, it seems necessary to raise the subfamily Gnesiocerotinae (emended) to family rank.

ECHINOPLANA Haswell, 1907

Diagnosis: Gnesiocerotidae without tentacles. Eyes disposed in two elongate groups. Pharynx mainly in anterior half of body, provided with 10-15 pairs of shallow lateral folds; intestinal branches ramify and anastomose. Male and female genital pores well separated by genital sucker with corrugated surface. Seminal vesicle elongate. Prostatic organ muscular and elongate, united with cirrus-sac by convoluted ejaculatory duct enclosed in mass of muscle fibres. Cirrus-sac with thick musculature and lined with spines gradually increasing in size towards the exterior. No male antrum. Vagina narrow, directed anteriorly, invested with "shell"-glands over much of its length. Lang's vesicle rudimentary. Uterine canals confluent in median line anteriorly to pharynx.

Type-species: *E. tenerrima* Haswell, 1907.

Type-locality: Port Jackson, N.S.W., Australia.

Remarks: Although *Echinoplana* has been defined by Haswell (1907), by Bock (1913) and by Galleni (1978), for one reason or another it was necessary to redefine it. Haswell regarded *Echinoplana* as a member of the Leptoplanidae, but Bock (1913) placed it in an appendix of the Planoceridae, and it has subsequently been generally accepted as a member of the latter family. In fact, Bresslau (1928) placed it in the subfamily Planocerinae, but du Bois—Reymond Marcus and Marcus (1968) referred it to a new planocerid subfamily Gnesiocerinae (sic).

Echinoplana tenerrima Haswell, 1907

Locality: South Australia—1 specimen (SAM/V2623), Point Brown, W. Zeidler, 9.viii.74; 1 specimen (SAM/V2624), west coast of Wittelbee Point. W. Zeidler, 2.iii.75; 1 specimen (SAM/V2622), under rocks, intertidal zone, Pondalowie Bay, W. Zeidler, 7.xi.76; 1 specimen (SAM/V2621), under rocks, low tide, Daly Heads, Yorke Peninsula, W. Zeidler, 9.xi.76.

Morphology: The elongate-oval body in the present material measures 12-22 mm long and 5-9 mm wide, and of a very light brown, with a dark reticulation. No nuchal tentacles. Eyes are arranged in two elongate groups, disposed laterally to the cerebral organ, each consisting of 30-50 eyes and tending to converge anteriorly. The tentacular eyes are situated in the posterior region of each group and are larger and appear nearer to the dorsal surface than the remaining (cerebral) eyes. The cerebral organ lies between the pharynx and the anterior margin of the body, but rather nearer to the pharynx. In fact, the arrangement of the eyes in relation to the cerebral organ agrees well with that depicted by Haswell (1907) and Galleni (1978).

The pharynx is situated in the second quarter of the total length of the body from the anterior margin. It is 3-5 mm long and possesses 10-14 pairs of shallow lateral folds. The intestinal trunk is about as long as the pharynx and gives off some 14-16 pairs of lateral branches, which ramify and anastomose towards the periphery of the body. The anterior end of the intestinal trunk trifurcates, a central branch passing anteriorly over the cerebral organ and the outer branches passing forwardly round the cerebral organ.

The male and female pores are well separated and situated in the third quarter of the body. Between them lies a corrugated area, probably functioning as a genital sucker. It is covered by a tall glandular epithelium supported by a thickening of the musculature of the body wall.

The vasa deferentia appear on either side of the anterior region of the pharynx, with which they run parallel. Immediately posterior to the pharynx, they converge towards the median line to open together into the posterior end of an elongate seminal vesicle, provided with a thin muscular wall. This vesicle lies ventrally, is directed anteriorly, and terminates in a narrow ejaculatory duct. The latter leads into the anterior end of the prostatic organ through a distinct papilla projecting into the lumen of the organ. The latter is elongate and two or three times larger than the seminal vesicle, dorsally to which it lies. It is provided with a thick inner layer of circular muscle fibres and an outer layer of longitudinal fibres and is lined with a tall glandular epithelium thrown into radial folds. The prostatic organ is directed posteriorly, and its hinder end narrows to continue as a much-convoluted ejaculatory duct invested with a thick layer of muscle fibres. The ejaculatory duct opens into a long cirrus-sac having a narrow lumen and lined with cuticular spines that gradually become larger towards the exterior. The cirrus-sac is coated with a very thick wall of radial muscles, among which circular and longitudinal muscles are scattered. There is no antrum masculinum, because the cirrus-sac opens directly to the exterior. The male pore or exterior opening of the cirrus-sac is situated at 6-10 mm from the posterior end of the body.

The female genital pore lies at 2-3 mm posteriorly to the male pore and opens into a narrow vagina externa or antrum femininum, lined with a glandular epithelium similar to that of the corrugated pad. The vagina extends dorsally, but soon curves anteriorly and immediately receives efferent ducts of the invest-

ing "shell"-glands to form a narrow "shell"-chamber. From this chamber, the vagina continues anteriorly as the vagina interna, lined with a low ciliated epithelium, to near the muscular mass of the cirrus-sac, dorsally to the male opening, where it makes a short posteriorly-directed dorsal loop. Shortly before terminating, the vagina receives a short common uterine canal, thus leaving a very short prolongation, mentioned by Haswell (1907) in his generic definition, as an "unsymmetrical diverticulum", but apparently comparable with the rudimentary Lang's vesicle found in some other polyclads. This very short narrow vesicle is lined with a tall ciliated epithelium, similar to that lining the uterine canals. Immediately before and after receiving the common uterine canal, the vagina is invested with innumerable eosinophilous gland-cells opening into the vagina and producing a secretion similar to that of the "shell"-glands—this is an unusual feature among polyclads, but it is known in the planocerid genus *Disparoplana* Laidlaw. From their common entrance into the vagina, the paired uterine canals extend anteriorly alongside the pharynx and vasa deferentia to a level between the cerebral organ and the pharynx, where they are confluent in the median line. The entire vaginal system is enclosed in a dense parenchyma packed with numerous muscle fibres.

Remarks: In the main, the specimen described above agrees with the description of this species given by Haswell (1907) and exceedingly well with the worm depicted by Galleni (1978). There are, however, one or two differences, for Haswell found the epithelium of the prostatic organ to be thrown into longitudinal folds, whereas this epithelium in the present specimen appears to be thrown into radial folds, and one of his figures (2) suggests that a branch of each vas deferens extends posteriorly beyond the male copulatory complex. Moreover, Haswell speaks of an "ootype", but this appears to be that which is generally referred to by authors on polyclads as the "shell" chamber.

In two serially sectioned specimens examined by Haswell, there was evidence of hypodermic injection of spermatozoa by other individuals through the epidermis in the region of the corrugated area or genital sucker, but in the present serially sectioned specimen no such evidence has been found.

Along the Australian coasts, *Echinoplana tenerrima* was known hitherto only from Port Jackson, N.S.W., where it appears to have been common more than seventy years ago. Recently, Galleni (1978) has described and figured specimens of this species from the Tuscan coast of Italy. Now that *E. tenerrima* appears to be widely distributed along the coast of South Australia, it seems reasonable to assume that the occurrence of this species in the warm-temperate waters of the Mediterranean is due to its being transported in a manner similar to that mentioned above for the North American polyclad *Euplana gracilis*.

Family CESTOPLANIDAE Lang, 1884

Cestoplana meridionalis Prudhoe, 1982

(Fig. 9)

Locality: South Australia—holotype (SAM/V2613-V2620 consisting of uncut portions and serial sections) and paratype (BM/1980.5.1.7), Beachport, W. Zeidler, 9.ii.77.

Morphology: The slender holotype measures 20 mm long and 3 mm wide at the broadest region near the posterior end of the body. It has more or less parallel sides and tapers towards both extremities. The ground colour of both dorsal and ventral surfaces in the preserved condition is greyish, but there is a tendency for the body to appear brownish, due to granules of chocolate-brown pigment in the epithelium, which when sloughed off the brownish colouration is lost. There is no indication of a ventral sucker or adhesive depression in the posterior region of the body. The bilobed cerebral organ lies at 1.25 mm from the anterior end of the body. Eyes appear in the median area of the body, at a short distance posteriorly to the cerebral organ and spread fanwise over the anterior region to the submarginal zones (Fig. 9A).

The mouth is situated at about 2.6 mm from the hinder end of the body and opens into the posterior region of a short pharyngeal chamber, which contains a slightly "ruffled" pharynx about 1 mm in length. The intestinal trunk is long, reaching anteriorly from behind the pharyngeal chamber to near the cerebral organ. It possesses numerous pairs of lateral branches, which ramify towards the margins of the body, but do not anastomose.

The male genital pore is situated at about 0.65 mm posterior to the mouth and 0.4 mm anterior to the female genital pore. The testes, unlike the ovaries, do not appear to extend into the post-pharyngeal region of the body. A pair of vasa deferentia lie on either side of the pharyngeal chamber and take a convoluted course posteriorly as far as the hinder level of the female copulatory complex, where they loop inwardly to run towards one another and near the male antrum they unite to form a short ejaculatory duct. This duct extends dorsally and soon opens into a muscular, elongate-oval, seminal vesicle, which is directed anteriorly and disposed ventrally to the intestinal trunk in the region between the genital pores. The anterior end of the seminal vesicle narrows abruptly to form a short duct, which leads into the proximal region of the prostatic organ. The latter is a small somewhat pyriform structure lined with a tall glandular epithelium and invested with a thick musculature, through which pass gland-cells opening into the lumen of the prostatic organ. This organ opens directly into

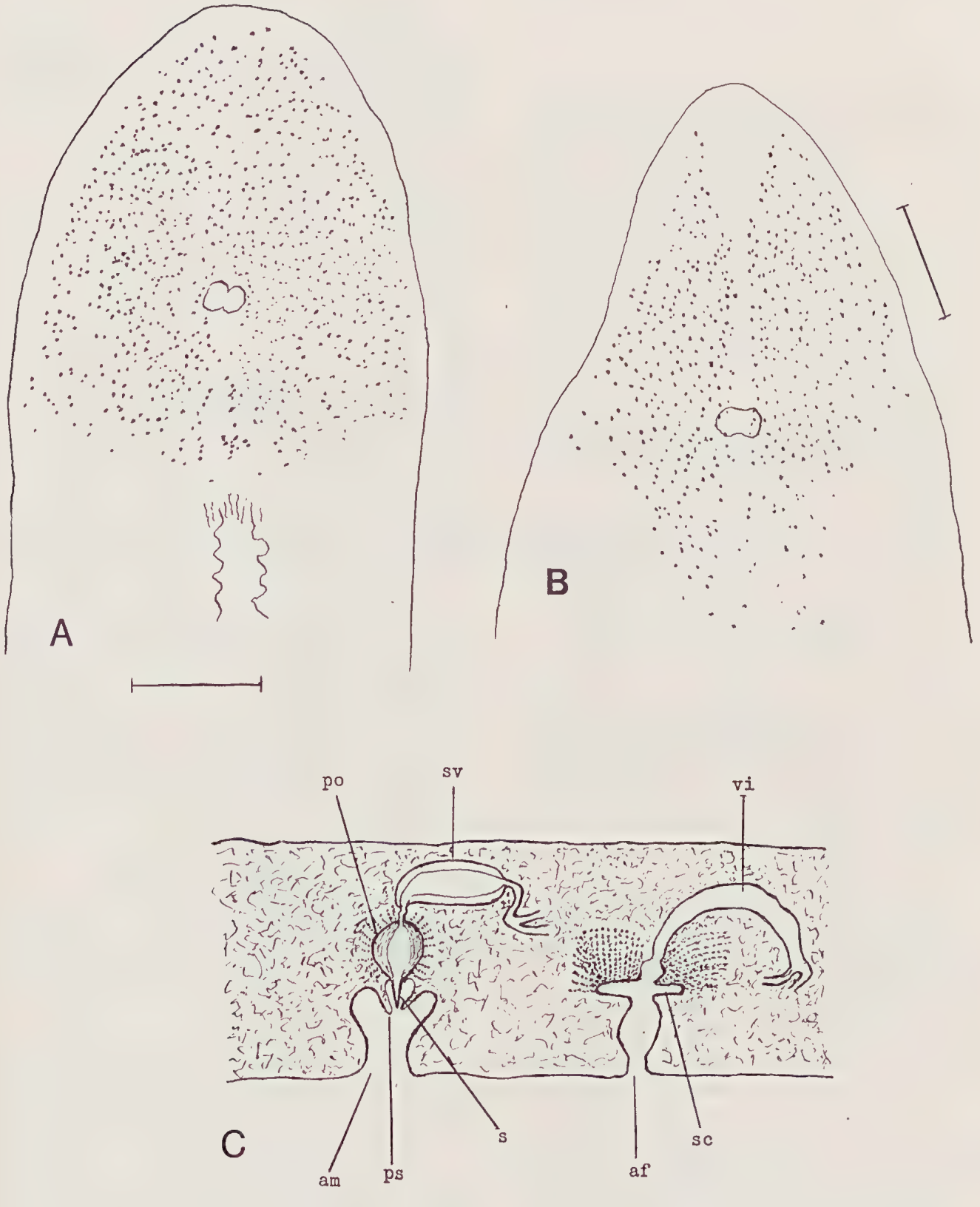

FIG. 9. *Cestoplana meridionalis*. A. Head-end of holotype (bar-scale-0.5 mm) B. Head-end of paratype (bar-scale-0.5 mm.) C. Sagittal section of copulatory complexes of holotype. *af.*, antrum femininum; *am.*, antrum masculinum; *po.*, prostatic organ; *ps.*, penis-sheath; *s.*, stylet; *sc.*, "shell"-chamber; *sv.*, seminal vesicle; *vi.*, vagina interna.

a small conical penis-papilla, tipped with a short spike of scleroid material. The armed penis-papilla is disposed vertically in a spacious penis-pocket which leads into the male antrum through a distinct penis-sheath. The male antrum is short, bulbous or somewhat pyriform.

The ovaries form a broad chain on either side of the median line and extend posteriorly from the cephalic region to near the hinder end of the body. The female genital opening is situated at about 1.5 mm from the posterior margin of the body. It opens into a narrow antrum femininum or vagina externa, which leads into a wide, dorso-ventrally compressed, "shell"-chamber. It seems that the efferent ducts of the "shell"-glands open into the chamber only through its dorsal wall and into a short portion of the distal region of the vagina interna. From the "shell"-chamber, the vagina interna, lined with a ciliated epithelium, makes a short posterior and downward curve to receive the uterine canals at its inner end. The uterine canals extend anteriorly from their union with the vagina, but are not yet fully developed.

The paratype specimen is also slender, but a little larger than the holotype, measuring 22 mm long and 3.5 mm wide. Its coloration is also chocolate-brown dorsally. The distribution of its eyes (Fig. 9B) is different from that in the holotype, inasmuch as there is a narrow median space, widening anteriorly, and devoid of eyes, a feature often seen in specimens of other species of *Cestoplana*. This apparent difference in the two present specimens probably arose because of a contraction of the cephalic region of the holotype at fixation. Although neither set of gonads has reached maturity, the male and female copulatory complexes are almost fully developed and are more or less comparable with those in the holotype.

Remarks: The diagnostic features of *Cestoplana meridionalis* are the chocolate-brown colouration of the body, the lack of a ventral adhesive pad posteriorly, the union of the vasa deferentia to form a common duct entering the seminal vesicle and the armed penis-papilla. The combination of these features enables this species to be readily differentiated from hitherto described species of *Cestoplana*.

Haswell (1907) erected the species *Cestoplana australis* for an immature polyclad found between the tide-marks at Woollahra Point, Port Jackson, N.S.W. Apparently it possesses a light ground colour, becoming reddish orange posteriorly. In addition, close to each lateral border there is a band of "vivid vermilion" and a median band of similar colour along the length of the body. Haswell recognized the very close resemblance of this species with the European *Cestoplana rubrocincta* (Grube, 1840,) and Kato (1944) has considered the two forms to be synonymous.

Family PSEUDOCEROTIDAE Lang, 1884 emend. Poche, 1926

Pseudoceros reticulatus Yeri and Kaburaki, 1918

Localities: South Australia—1 specimen (BM/1980.7.14), under stones, 5 m deep, Tipara Reef, 14 km west from Port Hughes, S.A. Shepherd; 1 specimen (AM/W17748), 5 m deep, Penneshaw, Kangaroo Island, N. Coleman, 12.iii.78.

Tasmania—several specimens (BM/1980.5.1.2-4 and AM/W17751), on reef, 5 m deep, Georges Bay, St Helens, N. Coleman, 6.10.77.

Morphology: The specimen from Tipara Reef is somewhat discoid in outline, measuring about 25 mm both long and wide, whereas the specimen from Kangaroo Island is oval in outline and measures 45 mm long and 25 mm wide. The several specimens from Tasmania are mainly a little smaller and distorted, but after some manipulation they were found to be oval in outline, measuring 18 mm-30 mm long and 10 mm-15 mm wide. The body is rather delicate, and the dorsal surface of the Tasmanian specimens is dark grey, has thick reticulation of grey or reddish brown, with much lighter interstices; ventrally the body is lighter than the dorsal surface, with no reticulation. In these specimens, the dorsal surface also shows many dark grey pigment spots of varying size, as well as numerous small dark spots, due to underlying ovaries. In fact, these specimens agree exceptionally well with the coloured figure of this species given by Yeri and Kaburaki (1918). In one or two specimens, there are indications of a whitish margin to the body, frequently interrupted by dull grey patches. A dark median band exists over the main-gut and is dappled with whitish patches. In a kodachrome taken by Neville Coleman, the living animal from Tasmania is translucent, brownish, with a diffusion of white over most of the dorsal surface of the body, interspersed with white spots. The white patches in the median band and the interruptions to the whitish marginal band observed in the preserved material are quite apparent in the living worm.

The specimens from South Australia are somewhat lighter in colour. They possess the dark median band, similarly dappled, and their marginal zones show a reticulation of grey, but the areas between the median band and the marginal zones are of a light yellowish brown. The dorsal surface is likewise spotted with dark grey pigment, but ventrally the spots are absent. The dark dots seen in the Tasmanian specimens are less apparent here, for the yolk material in the ovaries is much lighter in colour. In a kodachrome, also taken by N. Coleman, the living animal from Kangaroo Island appears translucent, brownish, with a greyish reticulation covering the dorsal surface.

A pair of tentacles appear as mere folds of the

anterior margin of the body and are tipped with white. Each tentacle contains numerous eyes beneath the dorsal and ventral surfaces, the number of which increases, with the size of the body. The cerebral eyes lie dorsally to the cerebral organ, and in the larger specimens they form a compact rounded group, whereas in the smaller specimens they appear to be arranged more or less in two semicircles disposed one behind the other.

The histological condition of the available material is not good, nevertheless the subepithelial musculature of the Tasmania material appears to consist of five layers of fibres, both dorsally and ventrally. There is an outer and an inner layer of longitudinal muscles and between them are two layers of muscles forming a criss-cross pattern enclosing a central layer of circular muscles.

The copulatory complexes are very similar in both sets of specimens and agree well with those described by Yeri and Kaburaki (1918). There is, however, one feature of disagreement, for in the original specimens the male copulatory complex lies closely posterior to the pharynx, whereas in the specimens of both the present sets the complex is situated ventrally to the hinder region of the pharynx, a feature possibly due to contraction at fixation.

Remarks: Pseudoceros reticulatus appears to be common in the warm-temperate waters of the east coast of Japan (Kato, 1944) and has been recorded from the coast of Vietnam (Dawydoff, 1952). Its occurrence in southern Australian waters indicates that this species is either widely distributed in the Indo-West Pacific region, or that it has been artificially transported by some means or other from the northern area of this region to southern Australia.

Pseudoceros lividus sp.nov.

Locality: South Australia—holotype (AM/W17750), on sponge, 5 m deep, Kingscote, Kangaroo Island, N. Coleman, 13.iii.78.

Morphology: The holotype has been preserved in formalin and is much contracted. It is oval in outline and is 5 mm long and 3 mm wide. It does not appear to be sexually mature. In a kodachrome taken by N. Coleman, the living worm is bluish, dorsally and ventrally, with a white margin. Because of the heavy pigmentation, it has not been possible to make out the arrangement of the eyes, even when an attempt was made to clear the worm in methyl salicylate. A small ventral sucker is centrally situated in the median line.

Remarks: Over 100 species of *Pseudoceros* have been described, mainly from the Indo-Pacific region. Hyman (1954) pointed out that the differentiation of species in this genus has been based almost solely on the pattern of coloration, although very little is known of variation in this feature. Nevertheless, two or three species have been described as showing much variety in colour, but there are one or two instances of where the pattern of coloration is remarkably constant.

Only two of the known species of *Pseudoceros* have a bluish ground colour and these are *P. concinnus* Stummer-Traunfels, 1933, *nec* (Collingwood, 1876) Kaburaki, 1923, and *P. tristriatus* Hyman, 1959. In both of these species, the dorsal surface is bluish with a median and two submarginal bands of yellow, and the present form being without any bands of coloration is regarded as a new species.

Thysanozoon skottsbergi Bock, 1923

Locality: South Australia—1 specimen (SAM/V2666), Beachport, W. Zeidler, 9.ii.77; 1 specimen (BM/1980.5.1.19), only "South Australia" known, S. A. Shepherd.

Remarks: Both specimens are mature and closely resemble those recorded by the present writer (1977) from Gun Island and Fremantle, Western Australia. *Thysanozoon skottsbergi* was originally recorded from Masatierra Island, one of the Juan Fernandez group, off the coast of Chile.

Family EURYLEPTIDAE Stimpson, 1857

Cycloporus australis Prudhoe, 1982

(Fig. 10)

Locality: South Australia—holotype (AM/W177499) and paratype (BM 1980.5.1.22), American River, Kangaroo Island, N. Coleman, 8.iii.78.

Morphology: The two specimens, preserved in formalin, are broadly oval in outline and measure 9-10 mm long and 6.5-7 mm wide. Dorsally, they are smooth and brownish, with widely-scattered dark spots, due to underlying ovaries, and a lighter coloured marginal band. In a kodachrome taken by N. Coleman of the two specimens when alive, both appear translucent and tinged with brown, with whitish spots scattered over the dorsal surface and yellowish patches distributed intermittently along the margins of the body. Again, we have an instance of where in the living animal the ovarian follicles are seen through the dorsal epidermis of the body as whitish dots, but when preserved in formalin the yolk-material in each follicle becomes darkened and the ovaries appear as dark spots. The ventral surface of the body is of a uniform lighter colour, except where the uterine canals filled with eggs appear as whitish lines on either side of the median line. A muscular ventral sucker lies in the middle region of the body.

The marginal tentacles, even when alive, according to the kodachrome, are inclined to be indefinite, and in the preserved condition they appear as slight folds

of the anterior margin of the body. Numerous eyes occur in the tentacles, more especially ventrally, while the numerous cerebral eyes lie over the cerebral organ in two distinct rectangular clusters, about twice as long as wide.

The dorsal epithelium of the body is taller than the ventral epithelium and tightly packed with rhabdite cells, each of which contains several rhabdites. The basement membrane is relatively thick, whereas the subepithelial musculature appears to be rather insignificant.

The mouth lies at about 1 mm from the anterior margin of the body, close behind the cerebral organ, and opens into a short pharyngeal chamber enclosing a campanulate pharynx. From the pharyngeal chamber, the median intestinal trunk extends to the posterior region of the body, giving off 8 or 9 pairs of lateral branches as it proceeds posteriorly. Anteriorly, the intestinal trunk trifurcates, a central branch passing directly over the cerebral organ and a pair of branches passing alongside the organ. The lateral intestinal branches ramify and anastomose rather loosely and terminate in numerous elongate vesicles in the marginal regions of the body. The vesicles open to the exterior through minute pores in the peripheral epithelium. It seems likely that the yellowish patches seen on the margins of the living animal are due to undigested material lying in the terminal vesicles of the digestive system.

The male genital pore is situated at 0.3 mm posterior to the mouth and the female pore 1.3 mm posterior to the male pore. The testes are widely distributed ventrally to the intestinal branches and reach to near the margins of the body. The vasa deferentia arise on either side of the median line at about midway between the female genital pore and the ventral sucker. Proximally, they are narrow thin-walled canals, but distally they are wide and lined with a well-developed glandular epithelium, an unusual feature in polyclads. On reaching anteriorly as far as the hinder margin of the pharyngeal chamber, they turn medially, narrow and, without uniting, open separately into a seminal vesicle. This vesicle is bulbous, with a thick muscular wall, and lies ventral to the hinder region of the pharyngeal chamber. From the seminal vesicle, a short ejaculatory duct extends anteriorly to open into a penis-papilla. The prostatic organ is an elongate oval structure lying between the pharyngeal chamber and the ejaculatory duct. It is considerably larger than the seminal vesicle, and is lined with a relatively tall glandular epithelium, invested with a well-developed musculature. From its anterior end, a short prostatic duct leads into the ejaculatory duct as it opens into the penis-papilla. This papilla is very small, but armed with a strong stylet lying in a muscular penis-pocket, which opens into a spacious antrum masculinum through a thick conical penis-sheath.

The widely scattered ovaries lie dorsal to the intestinal branches and extend to near the margins of the body. They are larger than the testes. The female copulatory complex presents the typical cotylean structure which seldom undergoes modification. The female genital pore opens into a widened antrum femininum or vagina externa, lined with a densely ciliated epithelium. The female antrum leads through a narrow aperture in its dorsal wall into a swollen dorsoventrally flattened "shell"-chamber, into which open the efferent ducts of innumerable investing "shell"-glands. From the "shell"-chamber, a muscular vagina interna extends dorsally to receive the common thin-walled uterine passage. A pair of symmetrically disposed uterine canals extends anteriorly as far as the male complex and then turns to run posteriorly to a short distance beyond the vaginal complex. The short uterine canals each bears 3 lateral uterine vesicles, suggesting that when the canals are fully developed and more elongate they may have about 9 pairs of vesicles.

Remarks: According to a differential key to the species of the genus *Cycloporus* Lang given by du Bois-Reymond Marcus and Marcus (1968), the present form bears a very strong resemblance to *C. gabriellae* Marcus, 1950, from Brazil and the Caribbean. Apart from a difference in coloration, the greater number of eyes enables *C. australis* to be readily differentiated from other species of the genus so far described. In their key, Marcus and Marcus did not include *C. maculatus* Hallez, 1893, which is distinguished by the cerebral and tentacular eyes merging to form an elongate cluster.

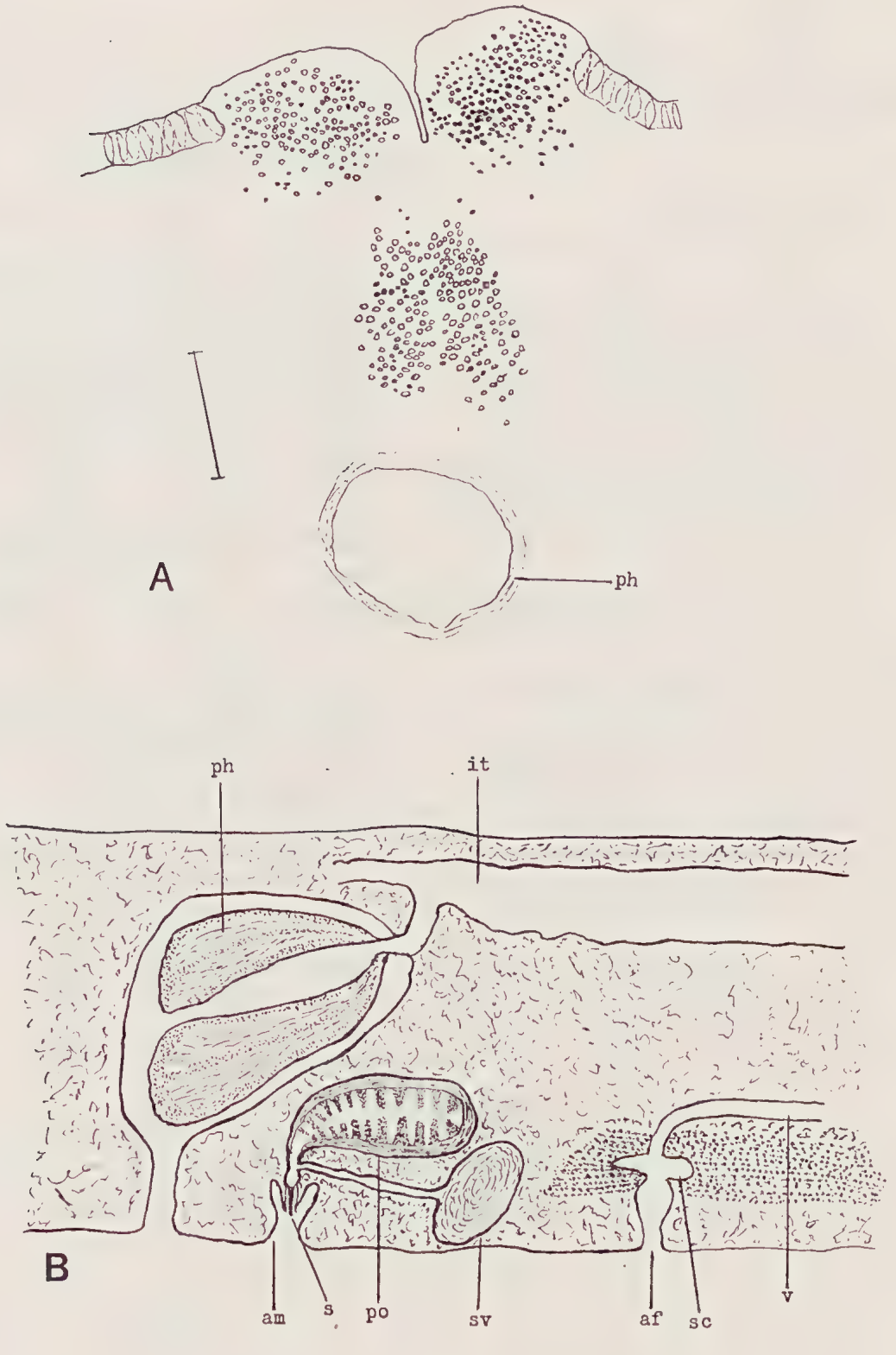

FIG. 10. *Cycloporus australis*. A. Arrangement of eyes. *ph.*, pharynx (bar-scale-0.5 mm) B. Sagittal section of copulatory complexes. *af.*, antrum femininum; *am.*, antrum masculinum; *it.*, intestinal trunk; *ph.*, pharynx; *po.*, prostatic organ; *s.*, stylet; *sc.*, "shell"-chamber; *sv.*, seminal vesicle; *v.*, vagina.

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HELMINTH TYPE SPECIMENS IN THE SOUTH AUSTRALIAN MUSEUM. I. NEMATODA

NATIONAL MUSEUM
14 JUN 1983
OF VICTORIA

by

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ABSTRACT

SMALES, L. R. 1983. Helminth type specimens in the South Australian Museum. I. Nematoda. *Rec. S. Aust. Mus.* **18** (17): 385-413. Type specimens of 412 species of Nematoda, held in the South Australian Museum or the Australian Helminthological Collection are catalogued. Species are organized into Superfamilies or Families and listed alphabetically according to the original name of the species. Where a name change has occurred the most recent acceptable name is included.

INTRODUCTION

This is the first of an intended series of papers listing the helminth types held by the South Australian Museum and the Australian Helminthological Collection.

The Museum's collection of helminths was established soon after the arrival in 1921 of T. Harvey Johnston to take up his appointment to the newly created Chair of Zoology at the University of Adelaide. He became an Honorary Curator of Helminthology in the Museum in 1922, a position he held until his death in 1951. As well as assuming an active role in the governing of the Museum (Board of Governors, 1927-39; Honorary Director of the Museum, 1928-31; Chairman of the Museum Board, 1940-51), he began to augment the Museum collections almost immediately. In addition he was co-author in a series of papers on the taxonomy of Australian helminths, the type material of which was eventually deposited in the Museum.

The first helminth registrations were three trematode holotypes in the Invertebrate "E" register in 1927 and five more types were registered there in the 1930's. A register for Vermes ("V") was started in 1935 and 23 helminth types, including eight transferred from the "E" register, were recorded in 1937 and 1938. Both registers then fell into disuse. Type material that had been deposited in the Museum was loaned to P. M. Thomas in 1951 and stored at the University for ready access and safe keeping. No further helminth material was registered until 1957 when 3 lots were recorded in the "E" register. There was a spasmodic flow of material from 1963 on. However it was not until 1974, following the removal of the marine invertebrates collections to the Museum's Goldsbrough House annex, and the appointment of W. Zeidler as Curator of Marine Invertebrates that any systematic attempt was made to register the now considerable collection of helminth types. He re-established the "V" register.

In 1977 responsibility for helminths was transferred to D. C. Lee, Curator of Arachnids. With the help of his assistant, A. M. Edwards, the back-log material was registered, in the "V" register, as well as material returned from the University. The collection, previously stored as accession lots, was arranged to reflect the systematic framework of the group by using a shelf number system prefixed by "HEL". Lee excluded annelids from the register and transferred all other registered helminths into the "V" register so that South Australian Museum numbers prefixed by V indicate helminths.

When T. H. Johnston arrived in Adelaide he already had a considerable private collection, mostly from Queensland and New South Wales. This was continually added to until his death, when responsibility for the now substantial collection, housed in the University of Adelaide, was assumed primarily by P. M. Thomas (nee Mawson) and L. M. Angel. By 1972 Professor J. Arundel (Veterinary Parasitology, University of Melbourne) had begun to express concern over the future of this valuable and still expanding collection. He commenced negotiations with the Australian Society of Parasitology in 1974 and in 1975 had begun the search for funding to provide permanent housing and curation.

Negotiations with the South Australian Museum resulted in an offer by the Museum to house the collection, without accepting responsibility for its curation. On the retirement of Miss Angel, from the University, in 1976, part of the collection was moved to the Museum, with Miss Angel as Honorary Associate to tend it. At the 1977 Annual General Meeting of the Australian Society of Parasitology a resolution was adopted that the collection should be properly housed and curated in a Museum. At the Annual General Meeting of 1978 the following proposals were adopted: that the Society would support an application from the Museum to the Australian Biological Study Resources Interim Council for funds to support a curator of the collection; that a committee be established to report on the collections of parasites held in Australia; that the committee seek an appropriate name for the collection. At the Annual General Meeting of 1979 the constitution was amended to include

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among the objects of the Society "..... foster establishment and proper curation of collections of Australian Parasites". The committee recommended at the 1980 Annual General Meeting in Perth that the collection be known as The Australian Helminthological Collection.

The remainder of the collection was moved to the Museum in 1980 when Mrs Thomas (now also an Honorary Associate of the Museum) retired from the University of Adelaide in 1980. Through the funding programme of the Bureau of Flora and Fauna, The Australian Biological Resources Study, grants have been made available for a temporary research assistant to undertake some curatorial work. However the long-term prospects for the safety of the collection remain in doubt. A survey of Australian collections conducted by D. M. Spratt for the Australian Society of Parasitology in 1979 indicated that the combined South Australian Museum Collection and Australian Helminthological Collection constituted considerably more than half the total helminth collection in this country. The index-catalogue of helminth species of the world, arranged by genera and cross-referenced for Australian hosts remains unique. New accessions continue to be received so that the collection now comprises over 11,000 bottles and some thousands of slides, most of which, as yet, remain uncatalogued.

Free-living species are listed separately under their family according to Filipjev, 1934. Parasitic forms, listed alphabetically under the original generic name, are grouped in superfamilies (also listed alphabetically) as designated by C I H Keys to the Nematode parasites of Vertebrates. Where a name change has occurred the most recent acceptable name is given, together with the relevant reference. Host species names are those used in the original descriptions. The following abbreviations were used in the text. BANZARE = British, Australia and New Zealand Antarctic Research Expedition, 1929-1931; N.T. = Northern Territory; N.S.W. = New South Wales; Qld = Queensland; S.A. = South Australia; S.A.M. = South Australian Museum; A.H.C. = Australian Helminthological Collection; Tas. = Tasmania; Vic. = Victoria; W.A. = Western Australia.

Individual collectors have not been acknowledged for each species because designations have not always been made in the literature. However the following people are known to have made substantial donations of nematode material: Dr T. L. Bancroft, Dr M. J. Mackerras, Mr A. S. LeSouef, Professor J. B. Cleland, Dr F. H. S. Roberts, Dr S. J. Edmonds, Mr B. Munday, Dr J. H. Arundel, Dr I. Beveridge, Dr D. M. Spratt and Mr R. Green. The preparators of the South Australian Museum and the Northern Territory Administration, Animal Industry Branch have also made substantial donations.

FREE LIVING NEMATODA

Family Chromadoridae

Harveyjohnstonia kartanum Mawson, 1953
Holotype ♂, allotype ♀ V3075
From littoral rock scrapings Pennington Bay, Kangaroo Island, S.A.
Trans. R. Soc. S. Aust., **76**: 39-40

Family Enoplidae

Metoncholaimus brevispiculum Mawson, 1957
Holotype ♂, allotype ♀ V3076
Jetty piles, Brighton, S.A.
Trans. R. Soc. S. Aust., **80**: 101-2

Pontonema hackingi Mawson, 1953
Holotype ♂ V1862, allotype ♀ V1863
Off Port Hacking, N.S.W.
Trans. R. Soc. S. Aust., **76**: 37-8

Symplocostomella johnstoni Mawson, 1953
Holotype ♀ V1861
Trawled at ?200 m, 5 miles east of Point Gibbon, N.S.W.
Trans. R. Soc. S. Aust., **76**: 38

Thoracostoma australe Mawson, 1953
Holotype ♂ V1859, allotype ♀ V1860
Dredging Station off Port Hacking, N.S.W.
Trans. R. Soc. S. Aust., **76**: 36

Family Monhysteridae

Steineria pulchra Mawson, 1957
Holotype ♂, allotype ♀ V3077
Weeds on jetty pile, Outer Harbor, S.A.
Trans. R. Soc. S. Aust., **80**: 103-5

PARASITIC NEMATODA

Superfamily Acuarioidea

Acuaria colluricinclae Mawson, 1972
Trans. R. Soc. S. Aust. **96** (3), p. 145
Holotype ♂, allotype ♀ V1511 from *Colluricincla rufiventris*
Gizzard: collected Eyre Peninsula, S.A.

Acuaria flindersi Johnston & Mawson, 1941
Trans. R. Soc. S. Aust. **65** (1), p. 31-2
Holotype ♂, allotype ♀ V1420 from *Hieracidea orientalis*
Gizzard: collected Flinders Is.

Acuaria microecae, Mawson, 1972
Trans. R. Soc. S. Aust. **96** (3), p. 145
Holotype ♂, allotype ♀ V1512 from *Microeca leucophaea*
Gizzard: collected Waikerie, S.A.

Acuaria mirafrae Mawson, 1972
Trans. R. Soc. S. Aust. **96** (3), p. 147
Holotype ♂, V1513 from *Mirafra javanica*
Gizzard: collected Northern Territory.
Paratypes AHC5226

Acuaria petterae Mawson, 1972
Trans. R. Soc. S. Aust. **96** (3), p. 144
Holotype ♂, allotype ♀ V1510 from *Lalage leucomela*
Gizzard: collected Katherine Gorge, N.T.
Paratypes AHC5219

Acuaria streperina Johnston & Mawson, 1941
Proc. Linn. Soc. N.S.W. **64** (3-4), p. 254-5
Holotype ♂, allotype ♀ V1432 from *Strepera melanoptera*
Gizzard: collected Waikerie, S.A.

Cheilonematodum halcyonis Johnston & Mawson, 1941
Proc. Linn. Soc. N.S.W. **66** (3-4), p. 253-4
Holotype ♂ V3045, allotype ♀ V3046 from *Halcyon sanctus*
Stomach: collected Milson Is., N.S.W.
Paratypes AHC900

Chevreuxia australis Johnston & Mawson, 1941
Trans. R. Soc. S. Aust. **65** (2), p. 259
Holotype ♀ V1446
Stomach: collected Tailem Bend, S.A.

Cosmocephalus australiensis Johnston & Mawson, 1952
Trans. R. Soc. S. Aust. **75**, p. 34-5
now *Synhimantus australiensis* (Johnston & Mawson, 1952) Beveridge & Barker 1975
Holotype ♂ V1866, allotype ♀ V1867 from *Hydromys chrysogaster*
Stomach: collected Tailem Bend, S.A.
Paratypes AHC1701

Cosmocephalus jaenschi Johnston & Mawson, 1941
Trans. R. Soc. S. Aust. **65** (2), p. 259
Holotype ♂ V1445, allotype ♀ V1452 from *Phalacrocorax carbo*
Stomach: collected Tailem Bend, S.A.

Dispharynx pelecani Johnston & Mawson, 1942
Rec. S. Aust. Mus. 7 (2), p. 185
now *Synhimantus (Dispharynx) pelecani* (Johnston & Mawson, 1942) Chabaud 1975
Holotype ♂, allotype ♀ V1453 from *Pelecanus conspicillatus*
Under lining of gizzard: collected Tailem Bend, S.A.

Echinuria querquedulae Johnston & Mawson, 1942
Trans. R. Soc. S. Aust. **66** (1), p. 71
Holotype ♂, allotype ♀ V1293 from *Querquedula gibberifrons*
Gizzard: collected Tailem Bend, S.A.

Paryseria diomedeae Johnston & Mawson, 1942
Trans. R. Soc. S. Aust. **66** (1), p. 69-70
now *Stegophorus diomedeae* (Johnston & Mawson, 1942) Johnston & Mawson, 1945
Holotype ♀, allotype ♂ V1349 from *Diomedea exulans*
Stomach: collected Port Jackson, N.S.W.
Paratypes AHC309, 366

Paryseria macronectes Johnston & Mawson, 1942
Trans. R. Soc. S. Aust. **66** (1), p. 70
now *Stegophorus macronectes* (Johnston & Mawson, 1942) Johnston & Mawson, 1945
Holotype ♀ V1348 from *Macronectes giganteus*
Stomach: collected Brighton, S.A.

Paryseria pachyptilae Johnston & Mawson, 1942
Trans. R. Soc. S. Aust. **66** (1), p. 70
now *Stegophorus pachyptilae* (Johnston & Mawson, 1942) Johnston & Mawson, 1945
Holotype ♀ V1346, allotype ♂ V1347 from *Pachyptilla vittata*
Stomach: collected Sellicks Beach, S.A.

Seuratia marina Johnston & Mawson, 1941
Trans. R. Soc. S. Aust. **65** (2), p. 259-60
Holotype ♂ V2824, allotype ♀ V2825 from *Pelagodroma marina*
Stomach: collected Flinders Is., Bass St.
Paratypes AHC995, 7798

Stammerinema suffodiax Beveridge & Barker, 1975
J: Helminth. **49**, p. 212-5.
Holotype ♂ V61, allotype ♀ V62 from *Antechinus stuartii*
Stomach: collected Sherbrook Forest, Vic.
Paratypes V63

Stegophorus heardi Mawson, 1953
Parasitology **43** (3-4), p. 295-6
Holotype ♂ V2898 from *Oceanites oceanicus*
Stomach: collected Heard Is.

Superfamily Ankylostomatoidea

Uncinaria hydromyidis Beveridge, 1980
J. Parasitol **66** (6) p. 1207-31
Holotype ♂ V1868, allotype ♀ V1869 from *Hydromys chrysogaster*
Small intestine; collected Daintree, Qld
Paratypes AHC6348 & V1870-87

Superfamily Aproctoidea

Aprocta bakeri Bain & Mawson, 1981
Rec. S. Aust. Mus. **18** (13) p. 269-71
Holotype ♂ V2100 from *Corvus orru*
Nasal cavity: collected Warwick, Qld

Aprocta boulengeri Bain & Mawson, 1981
Rec. S. Aust. Mus. **18** (13) p. 269
Holotype ♀ V2098, allotype ♂ V2099 from *Strepera graculina*
Head and nasal cavity: collected Qld

Aprocta corvicola Johnston & Mawson, 1940
Trans. R. Soc. S. Aust. **64** (2), p. 358
Holotype ♂, allotype ♀ V1402 from *Corvus coronoides*
Orbit: collected Musgrave Ranges, S.A.
Paratype AHC877

Austrofilaria vestibulata Johnston & Mawson, 1940
Trans. R. Soc. S. Aust. **64** (2), p. 357
now *Aprocta vestibulata* (Johnston & Mawson, 1940) Bain & Mawson, 1981
Holotype ♂, allotype ♀ V1406 from *Aphelocephala nigricinta*
Orbit: collected Musgrave Ranges, S.A.
Cotypes AHC878

Diomedenema diomedeae Johnston & Mawson, 1952
Trans. R. Soc. S. Aust. **75**, p. 32
Syntypes V2827 from *Diomedea chrysostoma*
Body cavity: collected Brighton, S.A.
Paratypes AHC310

Pseudaprocta copemani Bain & Mawson, 1981
Rec. S. Aust. Mus. **18** (3) p. 266-7
Holotype ♀ V2096, allotype ♂ V2097 from *Petroica multicolor*
Collected Maggs Mt., Tas.

Pseudaprocta myzanthae Johnston & Mawson, 1940
Trans. R. Soc. S. Aust. **64**, p. 358-9
Holotype ♀ V1403 from *Myzantha flavigula*
Body cavity: collected Renmark, S.A.

Superfamily Ascaridoidea

Anisakis kogiae Johnston & Mawson, 1939
Rec. S. Aust. Mus. **6** (3), p. 263-6
Holotype ♂, allotype ♀ V1337 from *Kogia breviceps*
Stomach: collected Port Victoria, S.A.

Contracaecum bancrofti Johnston & Mawson, 1941
Trans. R. Soc. S. Aust. **65** (1), p. 112-3
Holotype ♂, allotype ♀ V1433 from *Pelecanus conspicillatus*
Stomach: collected Burnett R., Qld

Contracaecum clelandi Johnston & Mawson, 1941
Trans. R. Soc. S. Aust. **65** (1), p. 113
Holotype ♂, allotype ♀ V1434 from *Pelecanus conspicillatus*
Stomach: collected Perth, W.A.

Contracaecum eudyptulae Johnston & Mawson, 1942
Proc. Linn. Soc. N.S.W. **67** (1-2), p. 93-4
Holotype ♂, allotype ♀ V1294 from *Eudyptula minor*
Digestive tract: collected Encounter Bay, S.A.
Paratypes AHC1709

Contracaecum magnicollare Johnston & Mawson, 1941
Trans. R. Soc. S. Aust. **65** (1), p. 114
Holotype ♂, allotype ♀ V1435 from *Anous stolidus*
Stomach: collected N-W Islet, Capricorn Group, Barrier Reef

Contracaecum murrayense Johnston & Mawson, 1940
Trans. R. Soc. S. Aust. **64** (2), p. 344
Holotype ♂, allotype ♀ V1391 from *Mccullochella macquariensis*
Stomach: collected Tailem Bend, S.A.
Paratypes AHC389

Contracaecum ogmorhinae Johnston & Mawson, 1941
Rec. S. Aust. Mus. **6** (4), p. 431-2
Holotype ♂, allotype ♀ V1268 from *Hydrurga leptonys*
Stomach: collected Port Adelaide, S.A.

Contracaecum podicipitis Johnston & Mawson, 1949
Trans. R. Soc. S. Aust. **73**, p. 67
Holotype ♂ V3047, allotype ♀ V3048 from *Podiceps cristatus*
Stomach: collected Tailem Bend, S.A.
Paratypes AHC306

Contracaecum sinulabiatum Johnston & Mawson, 1941
Trans. R. Soc. S. Aust. **65** (1), p. 113-114
Holotype ♂, allotype ♀ V1436 from *Plotus novaehollandiae*
Stomach: collected Burnett R., Qld
Paratypes AHC994

Goezia fluviatilis Johnston & Mawson, 1940
Trans. R. Soc. S. Aust. **64** (2), p. 342-3
Holotype ♂, allotype ♀ V1393 from *Plectroplites ambiguus*
Gill mucous: collected Tailem Bend, S.A.

Ophidascaris varani Johnston & Mawson, 1947
Trans. R. Soc. S. Aust. **71** (1), p. 23-4
now *Amplicaecum mackerrasae* (Johnston & Mawson, 1947) Thomas, 1959
Holotype ♂ V2876 from *Varanus varius*
Alimentary canal: collected Toowoomba, Qld
Paratypes AHC3154

Paraheterotyphlum australe Johnston & Mawson, 1948
Rec. S. Aust. Mus. **9** (1), p. 102-4
Holotype ♂, allotype ♀ V815 from *Hydrus platurus*
Intestine: collected Little Bay, Sydney, N.S.W.
Paratypes AHC1438

Paranisakis australis Johnston & Mawson, 1943
Trans. R. Soc. S. Aust. **67** (2), p. 190
Holotype ♂, allotype ♀ V1289 from *Urolophus australis*
Intestine: collected Sydney, N.S.W.

Phocascaris hydrurgae Johnston & Mawson, 1941
Rec. S. Aust. Mus. **6** (4), p. 432
now *Contracaecum osculatum* (Rud) Johnston & Mawson, 1945
Holotype V1272 from *Hydrurga leptonyx*
Stomach: collected Port Adelaide, S.A.
Note: Re-examination of *P. Hydrurgae* type material, by the authors, revealed it to be a pre-adult stage of *C. osculatum*

Porrocaecum circinum Johnston & Mawson, 1941
Trans. R. Soc. S. Aust. **65** (1), p. 30-1
Holotype ♀ V1418 from *Circus assimilis*
Intestine: collected Orroroo, S.A.

Porrocaecum clelandi Johnston & Mawson, 1941
Proc. Linn. Soc. N.S.W. **66** (3-4), p. 252
Holotype ♂, allotype ♀ V1425 from *Oreocincla lunulata*
Intestine: collected Bunya Mts, Qld

Porrocaecum kogiae Johnston & Mawson, 1939
Rec. S. Aust. Mus. **6** (3), p. 266
Holotype ♂, allotype ♀ V1338 from *Kogia breviceps*
Stomach: collected Spencer's Gulf, S.A.
Paratypes AHC1606

Porrocaecum lobibycis Mawson, 1968
Parasitology **58**, p. 284-5
Holotype ♂ V1467 from *Lobibyx novaehollandiae*
Duodenum: collected Naracoorte, S.A.
Paratypes AHC4495

Porrocaecum streperae Johnston & Mawson, 1941
Proc. Linn. Soc. N.S.W. **66** (3-4), p. 253
Holotype ♀ V1426 from *Strepera versicolor*
Intestine: collected Mt Kosiusko, N.S.W.

Stomachus oceanicus Johnston & Mawson, 1951
Rec. A. Mus. **22** (4), p. 293
now *Anisakis oceanicus* (Johnston & Mawson, 1951) Hartwich, 1974
Stomach: collected stranded on coast of N.S.W.
Paratypes AHC1699

Terranova chiloscyllii Johnston & Mawson, 1951
Rec. A. Mus. **22** (4), p. 291
from *Chiloscyllium punctatum*
Stomach: collected Halfway Is., Keppel Islands, Qld
Paratypes AHC1661

Superfamily Camallanoidea

Procamallanus murrayensis Johnston & Mawson, 1940
Trans. R. Soc. S. Aust. **64** (2), p. 347
Holotype ♂, allotype ♀ V1380 from *Pseudaphritis urvillei*
Alimentary canal: collected Swan Reach, S.A.

Superfamily Cosmocercoidea

Aplectana flindersi Johnston & Mawson, 1941
Rec. S. Aust. Mus. **7**, p. 148
now *Maxvachonia flindersi* (Johnston & Mawson, 1941) Mawson, 1972
Holotype ♂ V1408 from *Hyla jervisiensis*
Rectum: collected Kangaroo Is., S.A.

Cosmocera limnodynastes Johnston & Simpson, 1942
Trans. R. Soc. S. Aust. **66** (2), p. 174-6
Holotype ♀ V1275 from *Limnodynastes dorsalis*
Intestine: collected Adelaide, S.A.
Paratype AHC2372

Maxvachonia brygooi Mawson, 1972
Trans. R. Soc. S. Aust. **96** (2), p. 102-4
Holotype ♀ V1503 from *Amphibolurus decressi*
Rectum: collected Eyre Peninsula, S.A.

Maxvachonia chabaudi Mawson, 1972
Trans. R. Soc. S. Aust. **96** (2), p. 102
Holotype ♂, allotype ♀ V1502 from *Morethia lineoocellata*
Rectum: collected Eyre Peninsula, S.A.

Maxvachonia ewersi Mawson, 1972
Trans. R. Soc. S. Aust. **96** (2), p. 105-6
Holotype ♂, allotype ♀ V1504 from *Litoria nasuta*
Rectum: collected Brown R., New Guinea
Paratypes AHC5188

Spironoura hylae Johnston & Simpson, 1942
Trans. R. Soc. S. Aust. **66** (2), p. 173
now *Falcaustra simpsoni* (Johnston & Simpson, 1942) Chabaud, 1978
Holotype ♂ V2892, allotype ♀ V2893 from *Hyla aurea*
Intestine: collected Sydney, N.S.W.
Paratypes AHC2313
Note: *S. hylae* was found to be a nom praeocc. by Johnston & Mawson, 1944

Spironoura elseyae Johnston & Mawson, 1941
Rec. Aust. Mus. **21** (1). p. 15
now *Falcaustra elseyae* (Johnston & Mawson, 1941) Chabaud, 1978
from *Elseya dentata*
Intestine: collected Northern Australia
Paratypes AHC1666

Superfamily Dioctophymatoidea

Eustrongylides phalacrocoracis Johnston & Mawson, 1941
Trans. R. Soc. S. Aust. **65** (2), p. 255-6
Holotype ♂, allotype ♀ V1450 from *Phalacrocorax carbo*
Sub-peritoneal tissue of stomach: collected Tailem Bend, S.A.

Eustrongylides plotinus Johnston & Mawson, 1941
Trans. R. Soc. S. Aust. **65** (2), p. 256
Holotype ♂ V1451 from *Anhinga novaehollandiae*
Body cavity: collected Burnett R., Qld

Superfamily Diplotriaenoidea

Diplotriaena alpha Johnston & Mawson, 1940
Trans. R. Soc. S. Aust. **64** (2), p. 359-60
Holotype ♀ V1394 from *Strepera graculina*
Peritoneum: collected Mt Irvine, S.A.

Diplotriaena beta Johnston & Mawson, 1940
Trans. R. Soc. S. Aust. **64** (2), p. 360
Holotype ♀ V1395 from *Corvus coronoides*
Body cavity: collected Eidsvold, Qld

Diplotriaena beveridgei Bain & Mawson, 1981
Rec. S. Aust. Mus. **18** (3), p. 278-80
Holotype ♀ V2103, allotype ♂ V2104 from *Corvus orru*
Nasal cavity: collected Warwick, Qld

Diplotriaena delta Johnston & Mawson, 1940
Trans. R. Soc. S. Aust. **64** (2), p. 360
Holotype ♂ V1397 from *Malurus lamberti*
Body cavity: collected Ooldea, S.A.

Diplotriaena epsilon Johnston & Mawson, 1940
Trans. R. Soc. S. Aust. **64** (2), p. 360
Holotype ♂, allotype ♀ V1398 from *Cracticus destructor*
Body cavity: collected Brisbane, Qld

Diplotriaena gamma Johnston & Mawson, 1940
Trans. R. Soc. S. Aust. **64** (2), p. 360
Holotype ♀ V1396 from *Spres superbus*
Body cavity: collected Adelaide S.A.

Diplotriaena smithi Bain & Mawson, 1981
Rec. S. Aust. Mus. **18** (13), p. 280
Holotype ♀ V2105, allotype ♂ V2106 from *Acanthogenys rufogularis*
Collected the Bunkers, S.A.

Diplotriaena spratti Bain & Mawson, 1981
Rec. S. Aust. Mus. **18** (13), p. 277
Holotype ♀ V2101, allotype ♂ V2102 from *Oreoica gutteralis*
Body cavity: collected Petermann Ra., N.T.
Paratypes V2669-80

Diplotriaena zeta Johnston & Mawson, 1940
Trans. R. Soc. S. Aust. **64** (2), p. 361
Holotype ♀ V1399 from *Acanthogenys rufigularis*
Body cavity: collected Monarto, S.A.

Hamatospiculum chibiae Johnston & Mawson, 1941
Rec. A. Mus. **21** (1), p. 14-5
from *Chibia bracteata*
Skin of neck: collected Russell Is., Qld
Paratypes AHC1667

Hamatospiculum halcyonis Johnston & Mawson, 1941
Rec. A. Mus. **21** (1), p. 14
from *Halcyon pyrrhopygius*
Eye balls and roof of mouth: collected Mt Lyndhurst, S.A.
Paratypes AHC893, 1079

Hamatospiculum howense Johnston & Mawson, 1940
Trans. R. Soc. S. Aust. **64** (2), p. 355-6
Holotype ♂, allotype ♀ V1404 from *Halcyon vagans*
Sub-cutaneous tissue: collected Lord Howe Is.

Hamatospiculum mcneilli Johnston & Mawson, 1941
Rec. A. Mus. **21** (1), p. 12-14
from *Ninox boobook*
Tissues adjacent to skull: collected Hayman Is., Whitsunday Group, Qld.
Paratypes AHC862

Superfamily Dracunculoidea

Anguillicola australiensis Johnston & Mawson, 1940
Trans. R. Soc. S. Aust. **64** (2), p. 351
Holotype ♂, allotype ♀ V1392 from *Anguilla reinhardtii*
Swim bladder: collected Prospect Reservoir, Sydney, N.S.W.
Paratypes AHC586

Philometra plectroplites Johnston & Mawson, 1940
Trans. R. Soc. S. Aust. **64** (2), p. 348-9
Holotype ♀ V1384 from *Plectroplites ambiguus*
Body cavity: collected Murray Bridge, S.A.

Philometra percalates Johnston & Mawson, 1940
Trans. R. Soc. S. Aust. **64** (2), p. 349
Holotype ♂, allotype ♀ V1385 from *Percalates colonorum*
Body cavity: collected Tailem Bend, S.A.

Superfamily Filarioidea

Carinema dubia Johnston & Mawson, 1940
Trans. R. Soc. S. Aust. **64** (2), p. 357-8
now *Cardiofilaria dubia* (Johnston & Mawson, 1940) Sonin, 1961
Holotype ♂, allotype ♀ V1400 from *Pseudopsittacus mclennani*
Abdominal cavity: collected North Qld.

Carinema graucalinum Johnston & Mawson, 1940
Trans. R. Soc. S. Aust. **64** (2), p. 358
now *Cardiofilaria graucalinum* (Johnston & Mawson, 1940) Sonin, 1961
Holotype ♂, allotype ♀ V1401 from *Graucalus melanops*
Abdominal cavity: collected Fraser Is., Qld.

Dipetalonema annulipapillatum Johnston & Mawson, 1938
Trans. R. Soc. Aust. **62** (1), p. 117-8
now *Breinlia (Johnstonema) annulipapillatum* (Johnston & Mawson, 1938) Chabaud & Bain, 1976
Holotype ♂ V2826, allotype ♀ V31 from *Onychogale fraenata*
Sub-cutaneus: collected Burnett R., Qld
Note: Spratt & Varughese, 1975 found that the holotype of *D. annulipapillatum* was damaged, one spicule missing and badly discoloured.

Dipetalonema boltoni Spratt & Varughese, 1975
Aust. J. Zool. Suppl. Ser. **35**, p. 70-4
now *Breinlia (Breinlia) boltoni* (Spratt & Varughese, 1975) Chabaud & Bain 1976

Holotype ♂ V1130, allotype ♀ V1131 from *Macropus agilis*
Peritoneal cavity: collected Townsville, Qld
Paratype V1132

Dipetalonema dasyuri Johnston & Mawson, 1938
Trans. R. Soc. S. Aust. **62** (1), p. 109
now *Breinlia (Breinlia) dasyuri* (Johnston & Mawson, 1938) Chabaud & Bain, 1976
Holotype ♂, allotype ♀ V1126 from *Dasyurus viverrinus*
Body cavity: collected Vic.
Cotypes AHC2946

Dipetalonema dentonensis Spratt & Varughese, 1975
Aust. J. Zool. Suppl. Ser. **35**, p. 48-52
now *Breinlia (Breinlia) dentonensis* (Spratt & Varughese, 1975) Chabaud & Bain, 1976
Holotype ♂ V1141, allotype ♀ V1142 from *Macropus giganteus*
Subcutaneous connective tissue: collected 'Denton' Morella, Qld
Paratypes V1143

Dipetalonema lutreoli Mackerras, 1962
Aust. J. Zool. **10** (3), p. 406-9
now *Dipetalonema (Chenofilaria) johnstoni* (Mackerras, 1962) Chabaud & Bain, 1976
from *Rattus lutreolus*
Connective tissue: collected West Burleigh, Qld
Paratypes AHC3993

Dipetalonema mundayi Spratt & Varughese, 1975
Aust. J. Zool. Suppl. Ser. **35**, p. 67-70
now *Breinlia (Breinlia) mundayi* (Spratt & Varughese, 1975) Chabaud & Bain, 1976
Holotype ♂ V1144, allotype ♀ V1145 from *Macropus rufogriseus fruticus*
Pericardium: collected Ross, Tas.
Paratypes V1146

Dipetalonema pearsoni Spratt & Varughese, 1975
Aust. J. Zool. Suppl. Ser. **35**, p. 33-6
now *Dipetalonema (Chenofilaria) pearsoni* (Spratt & Varughese, 1975) Chabaud & Bain, 1976
Holotype ♂ V1139, allotype ♀ V1140 from *Isoodon macrourus*
Subcutaneous tissue: collected Woolwonga, N.T.

Dipetalonema pseudocheiri Spratt & Varughese, 1975
Aust. J. Zool. Suppl. Ser. **35**, p. 60-3
now *Breinlia (Breinlia) pseudocheiri* (Spratt & Varughese, 1975) Chabaud & Bain, 1976
Holotype ♂ V1127, allotype ♀ V1128 from *Pseudocheirus convolutor*
Peritoneal cavity: collected Launceston, Tas.
Paratypes V1129

Dipetalonema rarum Johnston & Mawson, 1938
Trans. R. Soc. S. Aust. **62** (1), p. 114
now *Breinlia (Breinlia) rarum* (Johnston & Mawson, 1938) Chabaud & Bain, 1976
Syntype ♀♀ V1123 from *Onychogale fraenata*
Subcutaneous: collected Vic.

Dipetalonema robertsi Johnston & Mawson, 1938
Rec. S. Aust. Mus. **6** (2), p. 188-9
now *Breinlia (Breinlia) robertsi* (Johnston & Mawson, 1938) Chabaud & Bain, 1976
Holotype ♂, allotype ♀ V1124 from *Macropus robustus*
Body cavity: collected Normanton, N. Qld

Dipetalonema tenue Johnston & Mawson, 1938
Trans. R. Soc. S. Aust. **62** (1), p. 118-20
now *Breinlia (Breinlia) robertsi* (Johnston & Mawson, 1938 after Spratt & Varughese, 1975) Chabaud & Bain, 1976
Holotype ♀ V1125 from *Macropus robustus*
Body cavity: collected Cockatoo Creek, N.T.

Dipetalonema venacavincola Spratt & Varughese, 1975
Aust. J. Zool. Suppl. Ser. **35**, p. 36-40
now *Sprattia venacavincola* (Spratt & Varughese, 1975) Chabaud & Bain, 1976
Holotype ♂ V1147, allotype ♀ V1148 from *Trichosurus caninus*
Inferior vena cava & heptic veins: collected Tamborine, Qld
Paratypes V1149

Johnstonema andersoni Spratt & Varughese, 1975
Aust. J. Zool. Suppl. Ser. **35**, p. 14-17
now *Breinlia (Johnstonema) andersoni* (Spratt & Varughese, 1975) Chabaud & Bain, 1976
Holotype ♂ V1135, allotype ♀ V1136 from *Megaleia rufa*
Subcutaneous connective tissue: collected Quilpie, Qld
Paratypes V1137

Johnstonema woerlei Spratt & Varughese, 1975
Aust. J. Zool. Suppl. Ser. **35**, p. 17-20
now *Breinlia (Johnstonema) woerlei* (Spratt & Varughese, 1975) Chabaud & Bain, 1976
Holotype ♂ V1138 from *Petrogale venustula*
Heart: collected Cannon Hill, N.T.

Josefilaria mackerrasse Moorhouse, Bain & Wolf, 1979
Annal. Parasit. Hum. et comp. **54** (6), p. 645-51
from *Macroderma gigas*
Fascia of pectoral muscles: collected Ridgeland, near Rockhampton, Qld
Paratypes V1913-4

Litomosa miniopteri Mackerras, 1962
Aust. J. Zool. **10** (3), p. 403-4
from *Miniopteris schreibersi*
Heart: Mt Pleasant, Qld
Paratypes AHC3994

Paralemdana clelandi Johnston & Mawson, 1940
Trans. R. Soc. S. Aust. **64** (2), p. 356-7
Holotype ♀ V1405 from *Strepera graculina*
Body cavity: collected Scone, N.S.W.

Piratuba queenslandensis Mackerras, 1962
Aust. J. Zool. **10** (3), p. 443
from *Varanus tristis orientalis*
Lungs: collected Innisfail, Qld
Paratypes AHC3995

Piratuba varanicola Mackerras, 1962
Aust. J. Zool. **10** (3), p. 444
from *Varanus tristis orientalis*
Pleural covering of lungs: collected Innisfail, Qld
Paratypes AHC4000

Saurofilaria innisfailensis Mackerras, 1962
Aust. J. Zool. **10** (3), p. 448
possibly now *Macdonaldius innisfailensis* (Mackerras, 1962) *Chabaud & Bain, 1976*
from *Physignathus leseurii*
Subperitoneal tissue: Innisfail, Qld
Paratypes AHC3966

Vagrifilaria australis Johnston & Mawson, 1942
Proc. Linn. Soc. N.S.W. **67** (1-2), p. 93
now *Aprocta australis* (Johnston & Mawson, 1942) Bain & Mawson, 1981
Holotype ♂, allotype ♀ V1295 from *Centropus phasianus*
Colon: collected West Burleigh, Qld

Superfamily Gnathostomatoidea

Tanqua ophidis Johnston & Mawson, 1948
Rec. S. Aust. Mus. **9** (1), p. 104-5
Holotype ♂ V2894, allotype ♀ V2895 from *Natrix mairii*
Alimentary canal: collected N-W coast, Qld
Paratypes AHC1441

Superfamily Habronematoidea

Ascarophis australis Johnston & Mawson, 1944
Trans. R. Soc. S. Aust. **68** (1), p. 62
Holotype ♂ V1255, allotype ♀ V1256 from *Threpterius maculosus*
Alimentary canal: collected Cape Border, S.A.

Ascarophis cooperi Johnston & Mawson, 1945
Trans. R. Soc. S. Aust. **69** (1), p. 115-6
Holotype ♂ V1257, allotype ♀ V1258 from *Platycephalus bassensis*
Alimentary canal: collected Rapid Bay, S.A.

Ascarophis murrayensis Johnston & Mawson, 1947
Rec. S. Aust. Mus. **8** (4), p. 553
Holotype ♂ V1253, allotype ♀ V1254 from *Plectroplites ambiguus*
Alimentary canal: collected Tailem Bend, S.A.

Crassicauda magna Johnston & Mawson, 1939
Rec. S. Aust. Mus. **6** (3), p. 266-8
Holotype ♀ V2833 from *Kogia breviceps*
Neck connective tissue: collected Pt Victoria, S.A.
Paratypes AHC1599, 1607

Cyrnea dentifera Johnston & Mawson, 1941
Proc. Linn. Soc. N.S.W. **66** (3-4), p. 255
now *Excisa dentifera* (Johnston & Mawson, 1941) Chabaud, 1958
Holotype ♂, allotype ♀ V1429 from *Eupodotis australis*
Gizzard: collected Mt Leibig, N.T.

Cyrnea (Procyrnea) dollfusi Mawson, 1968
Parasitology **58**, p. 750-2
now *Procyrnea dollfusi* (Mawson, 1968), Chabaud, 1975
Holotype ♂, allotype ♀ V1489 from *Ninox novaeseelandiae*
Gizzard: collected Berrimah, N.T.
Paratypes AHC4674

Cyrnea (P.) falco Mawson, 1968
Parasitology **58**, p. 752-3
now *Procyrnea falco* (Mawson, 1968) Chabaud, 1975
Holotype ♂, allotype ♀ V1490 from *Falco longipennis*
Gizzard: collected Humpty Doo, N.T.
Paratypes AHC4679

Cyrnea spiralis Mawson, 1968
Parasitology **58**, p. 753-5
now *Microhadjelia spiralis* (Mawson, 1968) comb. nova Mawson, pers. comm.
Holotype ♂, allotype ♀ V1491 from *Philemon argenticeps*
Gizzard: collected Berrimah, N.T.
Paratypes AHC4648

Excisa biloba Mawson, 1968
Parasitology **58**, p. 755-8
Holotype ♂, allotype ♀ V1492 from *Podargus strigoides*
Gizzard: collected Brisbane, Qld
Paratypes AHC4670

Geopetitia chibiae Mawson, 1966
Parasitology **56**, p. 716-7
Holotype ♀ V1455 from *Chibia bracteata*
Wall of proventriculus: Milner's Swamp, N.T.

Geopetitia falco Mawson, 1966
Parasitology **56**, p. 717-8
Holotype ♀ V1456 from *Falco longipennis*
Under lining of proventriculus: collected Humpty Doo, N.T.

Geopetitia streperae Mawson, 1966
Parasitology **56**, p. 715-6
Holotype ♂, allotype ♀ V1454 from *Strepera melanoptera*
Wall of proventriculus: collected Naracoorte, S.A.
Paratypes AHC4642

Habronema aegotheles Johnston & Mawson, 1941
Trans. R. Soc. S. Aust. **65** (2), p. 256-7
now *Alainchabaudia aegotheles* (Johnston & Mawson, 1941) Mawson, 1968

Holotype ♂, allotype ♀ V1447 from *Aegotheles cristata*
Under gizzard lining: collected Tailem Bend, S.A.

Habronema paraleptoptera Johnston & Mawson, 1941
Trans. R. Soc. S. Aust. **65** (1), p. 32-3
now *Cyrnea (Procyrnea) paraleptoptera* (Johnston & Mawson, 1941) Chabaud, 1958
Holotype ♂, allotype ♀ V1421 from *Cerchneis cenchroides*
Stomach: collected West Burleigh, Qld

Hedruris hylae Johnston & Mawson, 1941
Rec. S. Aust. Mus. **7** (1), p. 148
Holotype ♂, allotype ♀ V1261 from *Hyla jervisiensis*
Stomach: collected Kangaroo Is., S.A.

Hedruris longispicula Thomas, 1959
Trans. R. Soc. S. Aust. **82**, p. 160-1
Holotype ♀ V2829 from *Lygosoma challengeri*
Alimentary canal: collected Springbank, Qld
Note: The description of this species was published in the only paper by Mrs Thomas in which accidentally she did not use the name Mawson.

Microtetrameres aegotheles Mawson, 1977
Rec. S. Aust. Mus. **17** (14), p. 253
Holotype ♂, allotype ♀ V1540 from *Aegotheles cristata*
Proventriculus: collected Markanka, N.T.

Microtetrameres cacomantis Mawson, 1977
Rec. S. Aust. Mus. **17** (14), p. 253
Holotype ♂, allotype ♀ V1534 from *Cacomantis variolosus*
Proventriculus: collected Tobermory, N.T.

Microtetrameres cerci Mawson, 1977
Rec. S. Aust. Mus. **17** (14), p. 255
Holotype ♂ V1537 from *Circus assimilis*
Proventriculus: collected Petermann Ra., N.T.

Microtetrameres coracinae Mawson, 1977
Rec. S. Aust. Mus. **17** (14), p. 253
Holotype ♂, allotype ♀ V1530 from *Coracina novaehollandiae*
Proventriculus: collected Culburra, S.A.

Microtetrameres cractici Mawson, 1977
Rec. S. Aust. Mus. **17** (14), p. 251
Holotype ♂ V1528 from *Cracticus torquatus*
Proventriculus: collected Eyre Peninsula, S.A.

Microtetrameres eopsaltriae Mawson, 1977
Rec. S. Aust. 17 (**14**), p. 253
Holotype ♂, allotype ♀ V1536 from *Eopsaltria australis*
Proventriculus: collected Heatherleigh, S.A.

Microtetrameres gymnorhinae Mawson, 1977
Rec. S. Aust. Mus. **17** (14), p. 251
Holotype ♂, allotype ♀ V1538 from *Gymnorhina tibicen tibicen*
Proventriculus: collected Canberra, A.C.T.

Microtetrameres melophagidea Mawson, 1977
Rec. S. Aust. Mus. **17** (14), p. 248
Holotype ♂, allotype ♀ V1529 from *Acanthogenys rufogularis*
Proventriculus: collected Pt Augusta, S.A.
Paratypes AHC5914

Microtetrameres mirafrae Mawson, 1977
Rec. S. Aust. Mus. **17** (14), p. 249
Holotype ♂ V1535 from *Mirafra javanica*
Proventriculus: collected N.T.

Microtetrameres ninoctis Mawson, 1977
Rec. S. Aust Mus. **17** (14), p. 256
Holotype ♂, allotype ♀ V1525 from *Ninox novaezeelandiae*
Proventriculus: collected Berrimah, N.T.

Microtetrameres paraccipiter Mawson, 1977
Rec. S. Aust. Mus. **17** (14), p. 253
Holotype ♀ V1527 from *Accipiter fasciatus*
Proventriculus: collected Darwin, N.T.

Microtetrameres philemon Mawson, 1977
Rec. S. Aust. Mus. **17** (14), p. 249
Holotype ♂, allotype ♀ V1539 from *Philemon argenticeps*
Proventriculus: collected Coomalie Ck, N.T.

Microtetrameres raptoris Mawson, 1977
Rec. S. Aust. Mus. **17** (14), p. 255
Holotype ♂, allotype ♀ V1526 from *Falco peregrinus*
Proventriculus: collected Pt Augusta, S.A.
Paratypes AHC5906

Microtetrameres sphecotheres Mawson, 1977
Rec. S. Aust. Mus. **17** (14), p. 253
Holotype ♂ V1532 from *Sphecotheres flaviventris*
Proventriculus: collected Katherine Gorge, N.T.

Microtetrameres streperae Mawson, 1977
Rec. S. Aust. Mus. **17** (14), p. 251
Holotype ♂, allotype ♀ V1533 from *Strepera versicolor*
Proventriculus: collected Waikerie, S.A.

Microtetrameres tytonis Mawson, 1977
Rec. S. Aust. Mus. **17** (14), p. 257
Holotype ♂, allotype ♀ V1531 from *Tyto alba*
Proventriculus: collected Banka Banka, N.T.

Tetrameres anseranas Mawson, 1979
Trans. R. Soc. S. Aust. **103** (7), p. 178-80
Holotype ♂ V2681, allotype ♀ V2682 from *Anseranas semipalmata*
Proventriculus: collected Humpty Doo, N.T.
Paratypes AHC6941

Tetrameres australis Johnston & Mawson, 1941
Trans. R. Soc. S. Aust. **65** (2), p. 262
Holotype ♂, allotype ♀ V1451 from *Chenopsis atrata*
Proventriculus: collected Tailem Bend, S.A.

Tetrameres bizurae Johnston & Mawson, 1941
Trans. R. Soc. S. Aust. **65** (2), p. 261-2
Holotype ♂, allotype ♀ V1414 from *Biziura lobata*
Proventriculus: collected Tailem Bend, S.A.

Tetrameres calidris Mawson, 1968
Parasitology **58**, p. 300
Holotype ♂ V1410 from *Calidris canutus*
Proventriculus: collected Casuarina Beach, N.T.
Paratypes AHC4491

Tetrameres cladorhynchi Mawson, 1968
Parasitology **58**, p. 299-300.
Holotype ♂, allotype ♀ V1413 from *Chladorhynchus leucocephalus*
Proventriculus: collected St Kilda, Vic.
Paratypes AHC4514

Tetrameres dacelonis Mawson, 1979
Trans. R. Soc. S. Aust. **103** (7), p. 180
Holotype ♂ V2685, allotype ♀ V2686 from *Dacelo novaeguineae*
Proventriculus: collected Brisbane, Qld
Paratypes AHC6942

Tetrameres greeni Mawson, 1979
Trans. R. Soc. S. Aust. **103** (7), p. 180-2
Holotype ♂ V2683, allotype ♀ V2684 from *Pelecanus conspicillatus*
Proventriculus: collected Temmink, Brisbane, Qld

Tetrameres pelecani Johnston & Mawson, 1942
Trans. R. Soc. S. Aust. **66** (1), p. 72-3
Rec. S. Aust. Mus. **7** (2), p. 185-6
now *Microtetrameres pelecani* (Johnston & Mawson, 1942) Mawson, 1979
Holotype ♂ V1416, allotype ♀ (juvenile) V1417 from *Pelecanus conspicillatus*
Plesiotype ♀ V2719 as *Microtetrameres pelecani*
Trans. R. Soc. S. Aust. **103** (7), p. 178
Proventriculus: collected Brisbane, Qld and Tailem Bend, S.A.

Tetrameres scolopacidis Mawson, 1968
Parasitology **58**, p. 301-2
Holotype ♂, allotype ♀ V1412 from *Evolia acuminata*
Proventriculus: collected Woods Well, S.A.

Spinitectus bancrofti Johnston & Mawson, 1940
Trans. R. Soc. S. Aust. **64** (2), p. 345-6
Holotype ♂, allotype ♀ V1381 from *Mogurnda adspersa*
Intestine: collected upper Burnett R., Qld

Spinitectus percalates Johnston & Mawson, 1940
Trans. R. Soc. S. Aust. **64** (2), p. 345
now *Spinitectus plectroplites* (Johnston & Mawson, 1940) Johnston & Mawson, 1947
Holotype ♂, allotype ♀ V1382 from *Percalates colonorum*
Intestine: collected Lower Murray R., S.A.
Note: A new collection from the type host contained males of *S. plectroplites* not previously found and additional females. Examination of this material by the authors indicated that *S. percalates* falls as a synonym of *S. plectroplites.*

Spinitectus plectroplites Johnston & Mawson, 1940
Trans. R. Soc. S. Aust. **64** (2), p. 345
Holotype ♀ V1383 from *Plectroplites ambiguus*
Gill mucus: collected Tailem Bend, S.A.

Stellocaronema charadrii Mawson, 1968
Parasitology **58**, p. 294-6
Holotype ♂, allotype ♀ V1468 from *Charadrius cucullatus*
Under gizzard lining: collected Beachport, S.A.

Stellocaronema glareolae Mawson, 1968
Parasitology **58**, p. 296
Holotype ♀ V1469 from *Glareola isabella*
Under gizzard lining: collected Pt Augusta, S.A.
Paratypes AHC4498

Viguiera chabaudi Mawson, 1968
Parasitology **58**, p. 761-2
Holotype ♂, allotype ♀ V1494 from *Podargus strigoides*
Under gizzard lining: collected Blackwood, S.A.

Viguiera chibiae Mawson, 1968
Parasitology **58**, p. 763
Holotype ♂, allotype ♀ V1495 from *Chibia bracteata*
Under gizzard lining: collected Milner's Swamp, N.T.
Paratypes AHC4653

Viguiera longicollis Mawson, 1968
Parasitology **58**, p. 759-61
Holotype ♂, allotype ♀ V1493 from *Collurincincla rufiventris*
Under gizzard lining: collected Eyre Peninsula, S.A.

Superfamily Heterakoidea

Heterakis catheturinae T. H. Johnston, 1912
Proc. R. Soc. Qld. **24**, p. 73
from *Catheturinus lathami*
Caecum: collected Burnett R., Qld
Paratypes AHC272

Superfamily Metastrongyloidea

Antechinostrongylus disgubernaculus Spratt, 1981
J. Parasit. **67** (1) p. 91
Holoytpe ♂ V2066, allotype ♀ V2067 from *Antechinus swainsonii*
Lung: collected Nadgee Nature Reserve, N.S.W.
Paratypes V2068

Filaroides (Filaroides) pilbarensis Spratt, 1979
Aust. J. Zool. Suppl. Ser. **67** (5), p. 8-11
Holotype ♂ V1570, allotype ♀ V1571 from *Antechinus rosamundae*
Lungs: collected Woodstock Sth., W.A.
Paratypes V1572-80

Marsupostrongylus coulstoni Spratt, 1979
Aust. J. Zool. Suppl. Ser. **67**, p. 16-18
Holotype ♂ V1581, allotype ♀ V1582 from *Vombatus ursinus*
Terminal bronchioles of lungs: collected Lucyvale, Vic.
Paratypes V1583-4

Marsupostrongylus dorrigoensis Spratt, 1979
Aust. J. Zool. Suppl. Ser. **67**, p. 19-21
Holotype ♂ V1585, allotype ♀ V1586 from *Thylogale thetis*
Larger bronchioles of lung: collected Dorrigo, N.S.W.
Paratypes V1587-94

Marsupostrongylus lanceolatus Spratt, 1979
Aust. J. Zool. Suppl. Ser. **67**, p. 25-28
Holotype ♂ V1595, allotype ♀ V1596 from *Antechinus stuartii*
Terminal bronchioles, alveoli, lung parenchyma: collected Powelltown, Vic.
Paratypes V1597-8

Marsupostrongylus longilarvatus Spratt, 1979
Aust. J. Zool. Suppl. Ser. **67**, p. 28-31
Holotype ♂ V1599, allotype ♀ V1600 from *Wallabia bicolor*
Terminal bronchioles of lung: collected Bondi State Forest, N.S.W.
Paratypes V1601-7

Marsupostrongylus minesi Spratt, 1979
Aust. J. Zool. Suppl. Ser. **67**, p. 31-34
Holotype ♂ V1608, allotype ♀ V1609 from *Tricho surus ?caninus*
Terminal bronchioles of lung: collected Mt Glorious, Qld
Paratypes V1610-3

Parafilaroides hydrurgae Mawson, 1953
Parasitology **43** (304), p. 294
now *Filaroides (Parafilaroides) hydrurgae* (Mawson, 1953) Anderson, 1978
Holotype ♀ V2905 from *Hydrurga leptonyx*
Lung parenchyma: collected Heard Is.
Paratypes AHC3272

Superfamily Muspiceoidea

Durikainema macropi Spratt & Speare, (in press)
Holotype ♀ V2849, allotype ♂ V2850 from *Macropus giganteus*
Non-periferal blood: collected Durikai, Qld
Paratypes V2851-8

Riouxgolvania beveridgei Bain & Chabaud, 1979
Annales de Parasitol. **54** (2), p. 207-225
Holotype ♀ V1915 from *Miniopterus schreibersi*
Wing membrane: collected Palluma Dam, 120k N of Townsville, Qld

Superfamily Oxyuroidea

Aleuris brachylopi Johnston & Mawson, 1944
Trans. R. Soc. S. Aust. **68** (1), p. 61
Holotype ♂, allotype ♀ V1271 from *Brachylophus fasciatus*
Intestine: collected Fiji

Austroxyuris finlaysoni Johnston & Mawson, 1938
Rec. S. Aust. Mus. **6** (2), p. 191-3
Holotype ♂, allotype ♀ V24 from *Petauroides volans* var. *minor*
Caecum: collected Fitzroy R., Qld

Macropoxyuris brevigularis Mawson, 1964
Parasitology **54**, p. 257
Holotype ♂ V2882, allotype ♀ V2883 from *Macropus canguru*
Lower intestine: collected Cunnamulla, Qld

Macropoxyuris longigularis Mawson, 1964
Parasitology **54**, p. 253-6
Holotype ♂ V2880, allotype ♀ V2881 from *Macropus canguru*
Lower intestine: collected Cunnamulla, Qld

Oxyuris (s. l.) acuticaudata Johnston & Mawson, 1938
Rec. S. Aust. Mus. **6** (2), p. 194
now *Austroxyuris finlaysoni* (Johnston & Mawson, 1938) Mawson, 1964
Holotype ♀ V28 from *Petauroides volans* var. *minor*
Caecum and intestine: collected Fitzroy R., Qld

Oxyuris (s. l.) potoroo Johnston & Mawson 1939
Trans. R. Soc. S. Aust. **63** (2), p. 309
now *Potoroxyuris potoroo* (Johnston & Mawson, 1939) Mawson, 1964
Holotype ♀, allotype ♂ V1375 from *Potorous tridactylus*
Intestine: collected Gippsland, Vic.
Note: re-examination of the original material by Mawson revealed males which had not previously been described.

Parathelandros oedurae Johnston & Mawson, 1947
Trans. R. Soc. S. Aust. **71** (1), p. 25-6.
now *Skrjabinodon oedurae* (Johnston & Mawson, 1947) Inglis, 1968
Holotype ♂ V1245, allotype ♀ V1246 from *Oedura robusta*
Large intestine: collected West Burleigh, Qld

Passalurus parvus Johnston & Mawson, 1938
Rec. S. Aust. Mus. **6** (2), p. 193
now *Paraustroxyuris parvus* (Johnston & Mawson, 1938) Mawson, 1964
Holotype ♂ V25 from *Petauroides volans* var. *minor*
Intestine: collected Fitzroy R., Qld

Pharyngodon kartana Johnston & Mawson, 1941
Rec. S. Aust. Mus. **7** (1), p. 145-6
Holotype ♂, allotype ♀ V1260 from *Gymnodactylus milii*
Intestine: collected Kangaroo Is., S.A.
Paratypes AHC1655

Pharyngodon limnodynastes Johnston & Mawson, 1942
Proc. Linn. Soc. N.S.W. **67** (2), p. 94
Holotype ♀ V1409 from *Limnodynastes dorsalis dumerilli*
Intestine: collected Tailem Bend, S.A.

Skrjabinodon smythi Angel & Mawson, 1968
Trans. R. Soc. S. Aust. **92**, p. 69-70
Holotype ♂ V2884, allotype ♀ V2885 from *Phyllodactylus marmoratus*
Intestine: collected Port Gawler, S.A.
Paratype AHC8663

Syphacia trichosuri Johnston & Mawson, 1938
Rec. S. Aust. Mus. **6** (2), p. 194
now *Adelonema trichosuri* (Johnston & Mawson, 1938) Mawson, 1978
Holotype ♀ V29 from *Trichosurus vulpecula*
Allotype ♂ V3049 as *Adelonema trichosuri*
Trans. R. Soc. S. Aust. **102** (8), p. 223
Intestine: collected West Burleigh, Qld

Thelandros kartana Johnston & Mawson, 1941
Rec. S. Aust. Mus. **7**, p. 145
Holotype ♂ V1248, allotype ♀ V1244 from *Hemiergis peroni*
Paratypes V1244
Intestine: collected Kangaroo Is., S.A.

Thelandros trachysauri Johnston & Mawson, 1947
Trans. R. Soc. S. Aust. **71** (1), p. 24-5
Holotype ♂ V1242, allotype ♀ V1243 from *Trachysaurus rugosus*
Intestine: collected Adelaide, S.A.

Superfamily Physalopteroidea

Bancroftinema dentatum Johnston & Mawson, 1941
Trans. R. Soc. S. Aust. **65** (1), p. 33-4
Holotype ♀ V1422 from *Hieracidea berigora*
Stomach: collected Eidsvold, Qld

Paraleptus australis Johnston & Mawson, 1943
Trans. R. Soc. S. Aust. **67** (2), p. 188
Holotype ♂, allotype ♀ V1290 from *Heterodontus phillipi*
Alimentary canal: collected Pt. Willunga, S.A.

Physaloptera banfieldi Johnston & Mawson, 1941
Rec. Aust. Mus. **21** (1), p. 11
from *Melomys banfieldi*
Stomach: collected Dunk Is., Qld
Paratypes AHC1664

Physaloptera confusa Johnston & Mawson, 1942
Proc. Linn. Soc. N.S.W. **67**, p. 90-1
now *Abbreviata confusa* (Johnston & Mawson, 1942) Chabaud & Bain, 1976
Holotype ♂, allotype ♀ V1298 from *Notechis scutatus*
Stomach: collected Tailem Bend, S.A.

Physaloptera demansiae Johnston & Mawson, 1947
Rec. S. Aust. Mus. **9** (1), p. 105
now *Abbreviata demansiae* (Johnston & Mawson, 1947) Chabaud & Bain, 1976
Holotype ♂ V2871, allotype ♀ V2872 from *Demansia psammophis*
Stomach: collected Sydney, N.S.W.
Paratypes V2903-4

Physaloptera gallardi Johnston & Mawson, 1942
Rec. A. Mus. **21** (2), p. 114
now *Abbreviata gallardi* (Johnston & Mawson, 1942) Chabaud & Bain, 1976 from *Amphibolurus barbatus*
Intestine: collected Narrara, N.S.W.
Paratypes AHC2273

Physaloptera hieracideae Johnston & Mawson, 1941
Trans. R. Soc. S. Aust. **65** (1), p. 31
Holotype ♀ V1419 from *Hieracidea orientalis*
Gizzard: collected Flinders Is., Bass Strait.

Physaloptera papuensis Johnston & Mawson, 1940
Proc. Linn. soc. N.S.W. **65** (5-6), p. 475
Holotype ♂, allotype ♀ V1278 from ? bandicoot
Stomach: collected Mt Lamington, Papua New Guinea

Physaloptera parvicollaris Johnston & Mawson, 1940
Proc. Linn. Soc. N.S.W. **65** (5-6), p. 474-5
Holotype ♂, allotype ♀ V1280 from *Perameles nasuta*
Stomach: collected Sydney, N.S.W.

Physaloptera peragale Johnston & Mawson, 1940
Trans. R. Soc. S. Aust. **64** (1), p. 100
Holotype ♂, allotype ♀ V1278 from *Peragale minor*
Stomach: collected MacDonald Downs, N.T.
Paratypes AHC2664

Physaloptera sarcophili Johnston & Mawson, 1940
Proc. Linn. Soc. N.S.W. **65** (5-6), p. 474
Holotype ♂, allotype ♀, V1279 from *Sarcophilus harrisii*
Stomach: collected Tas. Biol. Survey

Physaloptera thalacomys Johnston & Mawson, 1940
Proc. Linn. Soc. N.S.W. **65** (5-6), p. 474
Holotype ♂, allotype ♀ V1277 from *Peragale minor*
Stomach: collected MacDonald Downs, N.T.

Proleptus trygonorrhinae Johnston & Mawson, 1943
Trans. R. Soc. S. Aust. **67** (2), p. 187-8
Holotype ♂, allotype ♀ V1288 from *Trigonorrhina fasciata*
Spiral valve: collected Pt. Willunga, S.A.

Proleptus urolophi Johnston & Mawson, 1951
Trans. R. Soc. S. Aust. **74** (1), p. 23
Holotype ♂ V2926, allotype ♀ V2927 from *Urolophus testaceus*
Spiral valve: collected Pt Jackson, N.S.W.

Skrjabinoptera goldmanae Mawson, 1970
Trans. R. Soc. S. Aust. **94**, p. 223-4
Holotype ♂, allotype ♀ V2811 from *Amphibolurus barbatus*

Stomach: collected Cobar, N.S.W.

Superfamily Rhabditoidea

Rhabdias hylae Johnston & Simpson, 1943
Trans. R. Soc. S. Aust. **66**, p. 176-8

Syntypes V2808 from *Hyla aurea*
Lung: collected Sydney, N.S.W.

Superfamily Rictularioidea

Rictularia carstairsi Mawson, 1971
Trans. R. Soc. Aust. **95** (2), p. 61-3
Holotype ♀ V2123, allotype ♂ V2124 from *Rattus villosissimus*
Duodenum and stomach: collected Brunette Downs Stn., N.T.
Paratypes AHC5032

Rictularia mackerrasae Mawson, 1971
Trans. R. Soc. S. Aust. **95** (2), p. 63-4
Holotype ♀ V1267 from *Rattus fuscipes assimilis*
Stomach: collected Innisfail, Qld

Rictularia pearsoni Mawson, 1971
Trans. R. Soc. S. Aust. **95** (3), p. 175-6
Allotype ♀ V2870 from *Rattus fuscipes murrayi*
Stomach: collected Pearson Is., S.A.

Rictularina spinosa Johnston & Mawson, 1941
Proc. Linn. Soc. N.S.W. **66**, p. 254
Holotype ♀ V1424 from *Myiagra rubecula*
Stomach: collected Stradbroke Is., Qld

Superfamily Seuratoidea

Cucullanus heterodonti Johnston & Mawson, 1943
Trans. R. Soc. S. Aust. **67** (2), p. 187
Holotype ♂, allotype ♀ V1291 from *Heterondontus phillips*
Intestine: collected Port Willunga, S.A.

Cucullanellus cnidglanis Johnston & Mawson, 1945
Trans. R. Soc. S. Aust. **69** (1), p. 116
now *Dichelyne (Cucullanellus) cnidglanis* (Johnston & Mawson, 1945) Petter, 1974
Holotype ♂ V1249, allotype ♀ V1250 from *Cnidoglanis megastomus*
Intestine: collected Port Willunga, S.A.

Cucullanellus sheardi Johnston & Mawson, 1944
Trans. R. Soc. S. Aust. **68** (1), p. 64
now *Dichelyne (Cucullanellus) sheardi* (Johnston & Mawson, 1944) Petter, 1974
Holotype ♂ V1251, allotype ♀ V1252 from *Threpterius maculosus*
Intestine: collected Cape Borda, S.A.

Echinonema edmondsi Chabaud et al. 1980
Annales de Parasit. **55** (4), p. 433-5
Holotype ♂ V2071, allotype ♀ V2072 from *Dasyurus hallucatus*
Stomach and small intestine: collected Cannon Hill, N.T.
Paratypes V2073-91

Echinonema meridionalis Chabaud et al. 1980
Annales de Parasit. **55** (4), p. 436-7 from *Isoodon obesulus*
Alimentary canal: collected Waitpinga, S.A.
Cotypes V2932 & AHC4460

Inglisonema typos Mawson, 1968
Parasitology **58**, p. 71-3
Holotype ♂, allotype ♀ V1697 from *Pitta versicolor*
Stomach: collected Swainson, Qld

Paraseuratum tandani Johnston & Mawson, 1940
Trans. R. Soc. S. Aust. **64** (2), p. 347-8
Holotype ♂, allotype ♀ V1389 from *Tandanus tandanus*
Alimentary canal: collected Tailem Bend, S.A.

Seuratinema brevicaudatum Johnston & Mawson, 1941
Trans. R. Soc. S. Aust. **65** (1), p. 33
now *Skrjabinura brevicaudatus* (Johnston & Mawson, 1941)
Mawson, 1960
Holotype ♂ V1685 from *Ninox connivens*
Alimentary canal: collected Burnett R., Qld

Seuratinema magnum Johnston & Mawson, 1941
Proc. Linn. Soc. N.S.W. **66** (3-4), p. 256
now *Skrjabinura magnum* (Johnston & Mawson, 1941) Mawson, 1960
Holotype ♀ V1427 from *Dacelo gigas*
Alimentary canal: collected Pilliga Scrub, N.S.W.

Seuratinema pomatostomi Johnston & Mawson, 1941
Proc. Linn. Soc. N.S.W. **66** (3-4), p. 255-6
now *Skrjabinura pomatostomi* (Johnston & Mawson, 1941) Mawson, 1960
Holotype ♂, allotype ♀ V1428 from *Pomatostomus superciliosus*
Alimentary canal: collected Baradine, N.S.W.

Seurechina chaneeti Chabaud et al, 1980
Annales de Parasit. **55** (4), p. 429-31
Holotype ♀ V2069, allotype ♂ V2070 from *Dasyurus hallucatus*
Intestine: collected Koolan Is., W.A.

Superfamily Spiruroidea

Alainchabaudia alcedinis Mawson, 1968
Parasitology **58**, p. 741-2
Holotype ♂, allotype ♀ V1488 from *Halcyon sanctus*
Gizzard: collected Brisbane, Qld

Cyathospirura dasyuridis Mawson, 1968
Parasitology **58**, p. 77-8
Holotype ♂, allotype ♀ V1508 from *Dasyurops maculatus*
Stomach: collected N.S.W.
Paratypes AHC5194

Gongylonema alecturae Johnston & Mawson, 1942
Proc. Linn. Soc. N.S.W. **67** (1-2), p. 92-3
Holotype ♂, allotype ♀ V1296 from *Alectural lathami*
No host site data: collected Eidsvold, Qld

Gongylonema beveridgei Mawson, 1971
Trans. R. Soc. S. Aust. **95** (3), p. 176-7
Holotype ♂ V2822, allotype ♀ V2823 from *Rattus fuscipes murrayi*
Stomach: collected Pearson Is., S.A.
Paratypes AHC7799

Protospirura marsupialis Baylis, 1927
Rec. S. Aust. Mus. **6** (2), p. 190-1
Allotype ♂ V30 (Johnston & Mawson, 1938) from *Trichosurus vulpecula*
Stomach: collected Eidsvold, Qld

Superfamily Strongyloidea

Beveridgea corneri Mawson, 1980
Trans. R. Soc. S. Aust. **104** (4), p. 81
Holotype ♂, allotype ♀ V1910 from *Macropus agilis*
Stomach: collected Elizabeth Downs, N.T.
Paratypes AHC7801

Buccostrongylus australis Johnston & Mawson, 1939
Trans. R. Soc. S. Aust. **63** (3), p. 142
Holotype ♂, allotype ♀ V1558 from *Macropus wilcoxi*
Stomach: collected Eidsvold, Qld

Buccostrongylus buccalis Johnston & Mawson, 1939
Trans. R. Soc. S. Aust. **63** (3), p. 141-2
Holotype ♂, allotype ♀ V1557 from *Macropus dorsalis*
Stomach: collected Upper Burnett District, Qld

Buccostrongylus labiatus Johnston & Mawson, 1939
Proc. Linn. Soc. N.S.W. **64** (5-6), p. 527
Holotype ♂, allotype ♀ V1371 from *Macropus ruficollis*
Stomach: collected Bathurst district, N.S.W.
Paratypes AHC7291

Buccostrongylus setifer Johnston & Mawson, 1939
Proc. Linn. Soc. N.S.W. **64** (5-6), p. 527-8
Holotype ♂ V2815, allotype ♀ V2816 from *Macropus ruficollis*
Stomach: collected Bathurst, N.S.W.

Cassunema exigua Beveridge & Johnston, 1981
Systematic Parasit. **3**, p. 78-80
Holotype ♂ V1994, allotype ♀ V1995 from *Thylogale stigmatica*
Stomach: collected Tolga, Qld
Paratypes V1996-05

Cloacina annulata Beveridge, 1979
J. Helminth. **53**, p. 369-70
Holotype ♂ V1645, allotype ♀ V1646 from *Wallabia bicolor*
Stomach: collected Bellbird Ck., Vic.
Paratypes V1647-50

Cloacina australis Johnston & Mawson, 1938
Trans. R. Soc. S. Aust. **62** (2), p. 275
now *Cloacina daveyi* (Johnston & Mawson, 1938) Mawson, 1977
Holotype ♂, allotype ♀ V1358 from *Macropus robustus*
Stomach: collected Mt Liebig, N.T.
Note: Mawson examined specimens identified as *Macropostrongylus australis* Yorke & Maplestone, 1926 by Baylis (1934). She re-described the species from this material and additional specimens from the same host in Papua. From Yorke & Maplestone's figures *M. australis* appeared to be referable to *Cloacina* as were the specimens identified by Baylis. As *C. australis* (Yorke & Maplestone) predated *C. australis* Johnston & Mawson, 1938 Mawson proposed *C. daveyi* as the new name.

Cloacina bancroftorum Johnston & Mawson, 1939
Trans. R. Soc. S. Aust. **63** (3), p. 133
Holotype ♂, allotype ♀ V1551 from *Macropus dorsalis*
Stomach: collected upper Burnett R., Qld

Cloacina burnettiana Johnston & Mawson, 1939
Trans. R. Soc. S. Aust. **63** (3), p. 130-1
Holotype ♂, allotype ♀ V1548 from *Macropus dorsalis*
Stomach: collected upper Burnett R., Qld

Cloacina castor Beveridge, 1979
J. Helminth. **53**, p. 364-7
Holotype ♂ V1651, allotype ♀ V1652 from *Wallabia bicolor*
Stomach: collected Teesdale, Vic.
Paratype V1653

Cloacina clarkae Mawson, 1972
Trans. R. Soc. S. Aust. **96** (2), p. 109-112
Holotype ♂, allotype ♀ V1506 from *Macropus eugenii*
Stomach: collected Kangaroo Is., S.A.

Cloacina communis Johnston & Mawson, 1938
Trans. R. Soc. S. Aust. **62** (2), p. 275-277
Holotype ♂, allotype ♀ V1355 from *Macropus robustus*
Stomach: collected Mt Liebig, N.T.
Paratypes AHC8143

Cloacina curta Johnston & Mawson, 1938
Trans. R. Soc. S. Aust. **62** (2), p. 279-280
Holotype ♂, allotype ♀ V1354 from *Macropus robustus*
Stomach: collected Mt Liebig, N.T.

Cloacina digitata Johnston & Mawson, 1940
Proc. Linn. Soc. N.S.W. **65** (5-6), p. 469
Holotype ♂, allotype ♀ V1282 from *Macropus dorsalis*
Stomach: collected Burnett R., Qld

Cloacina dubia Johnston & Mawson, 1938
Trans. R. Soc. S. Aust. **62** (2), p. 280-1
Holotype ♂, allotype ♀ V1357 from *Macropus robustus*
Stomach: collected Mt Liebig, N.T.

Cloacina edwardsi Mawson, 1972
Trans. R. Soc. S. Aust. **96** (2), p. 112
Holotype ♂, allotype ♀ V1507 from *Wallabia bicolor*
Stomach: collected Sunday Is., Vic.

Cloacina elegans Johnston & Mawson, 1938
Trans. R. Soc. S. Aust. **62** (2), p. 271-2
Holotype ♂, allotype ♀ V1247 from *Petrogale lateralis*
Stomach: collected Hermansburg, N.T.

Cloacina ernabella Johnston & Mawson, 1938
Trans. R. Soc. S. Aust. **62** (2), p. 281-2
Holotype ♂, allotype ♀ V1351 from *Petrogale lateralis*
Stomach: collected Ernabella, S.A.

Cloacina expansa Johnston & Mawson, 1939
Proc. Linn. Soc. N.S.W. **64** (5-6), p. 529
Holotype ♂, allotype ♀ V1564 from *Macropus major*
Stomach: collected Coonamble, N.S.W.

Cloacina frequens Johnston & Mawson, 1938
Trans. R. Soc. S. Aust. **62** (2), p. 273-4
Holotype ♂, allotype ♀ V1359 from *Macropus robustus*
Stomach: collected Mt Liebig, N.T.

Cloacina gallardi Johnston & Mawson, 1940
Proc. Linn. Soc. N.S.W. **65** (5-6), p. 470
Holotype ♂, allotype ♀ V1283 from *Macropus ualabatus*
Stomach: collected Ourimbah, N.S.W.

Cloacina hydriformis Johnston & Mawson, 1938
Trans. R. Soc. S. Aust. **62** (2), p. 273
Holotype ♂, allotype ♀ V1364 from *Macropus robustus*
Stomach: collected Mt Liebig, N.T.
Paratypes AHC1841

Cloacina inflata Johnston & Mawson, 1938
Trans. R. Soc. S. Aust. **62** (2), p. 285-6
Holotype ♂, allotype ♀ V1353 from *Macropus rufus*
Stomach: collected Mt Liebig, N.T.

Cloacina kartana Mawson, 1975
Trans. R. Soc. S. Aust. **99** (1), p. 40-1
Holotype ♂, allotype ♀ V1266 from *Macropus eugenii*
Stomach: collected Kangaroo Is., S.A.
Paratypes AHC5829

Cloacina liebigi Johnston & Mawson, 1938
Trans. R. Soc. S. Aust. **62** (2), p. 284-5
Holotype ♂, allotype ♀ V1363 from *Macropus rufus*
Stomach: collected Mt Liebig, N.T.

Cloacina linstowi Johnston & Mawson, 1940
Proc. Linn. Soc. N.S.W. **65** (5-6), p. 469-70
Holotype ♂, allotype ♀ V1284 from *Macropus ruficollis*
Stomach: collected Burnett R., Qld

Cloacina longispiculata Johnston & Mawson, 1939
Trans. R. Soc. S. Aust. **63** (3), p. 131-2
Holotype ♂, allotype ♀ V1550 from *Macropus agilis*
Stomach: collected Gregory R., Carpentaria District, Qld

Cloacina macropodis Johnston & Mawson, 1938
Trans. R. Soc. S. Aust. **62** (2), p. 278-9
Holotype ♂, allotype ♀ V1356 from *Macropus robustus*
Stomach: collected Mt Liebig, N.T.

Cloacina magna Johnston & Mawson, 1938
Trans. R. Soc. S. Aust. **62** (2), p. 277
now *C. cummunis* (Johnston & Mawson, 1938) Mawson, 1961
Holotype ♂, allotype ♀ V1362 from *Macropus robustus*
Stomach: collected Cockatoo Ck., N.T.

Cloacina magnipapillata Johnston & Mawson, 1939
Proc. Linn. Soc. N.S.W. **64** (5-6), p. 350
Holotype ♂, allotype ♀ V1566 from *Macropus major*
Stomach: collected Coonamble, N.S.W.

Cloacina mawsonae Beveridge, 1979
J. Helminth. **53**, p. 364-7
Holotype ♂ V1619, allotype ♀ V1620 from *Wallabia bicolor*
Stomach: collected Bonang, Vic.
Paratypes V1621-4

Cloacina minor Johnston & Mawson, 1938
Trans. R. Soc. S. Aust. **62** (2), p. 283
now *Cloacina longelabiata* (Johnston & Mawson, 1938) Johnston & Mawson, 1939
Holotype ♂, allotype ♀ V1360 from *Macropus robustus*
Stomach: collected Mt Liebig, N.T.
Note: the authors assignment of *Macropostrogylus minor* Davey & Wood, 1938 to *Cloacina* necessitated the renaming *C. minor* Johnston & Mawson

Cloacina mundayi Mawson, 1972
Trans. R. Soc. S. Aust. **96** (2), p. 109
Holotype ♂, allotype ♀ V1505 from *Macropus rufogrisea*
Stomach: collected Tarraleah, Tas.

Cloacina obtusa Johnston & Mawson, 1939
Proc. Linn. Soc. N.S.W. **64** (5-6), p. 530
Holotype ♂, allotype ♀ V1565 from *Macropus major*
Stomach: collected Coonamble, N.S.W.

Cloacina papillata Beveridge, 1979
J. Helminth. **53**, p. 367-8
Holotype ♂ V1625, allotype ♀ V1626 from *Wallabia bicolor*
Stomach: collected Marlborough, Qld
Paratypes V1627-44

Cloacina parva Johnston & Mawson, 1938
Trans. R. Soc. S. Aust. **95** (3), p. 171
from *Petrogale pearsoni*
Stomach: collected Pearson Is.
Paratypes AHC6983

Cloacina petrogale Johnston & Mawson, 1938
Trans. R. Soc. S. Aust. **62** (2), p. 277-8
Holotype ♂ V2896, allotype ♀ V2897 from *Petrogale lateralis*
Stomach: collected Mt Liebig, N.T.
Paratypes AHC1846

Cloacina pollux Beveridge, 1979
J. Helminth. **53**, p. 375-6

Holotype ♂ V1654, allotype ♀ V1655 from *Wallabia bicolor*
Stomach: collected Townsville, Qld
Paratypes V1656-70

Cloacina robertsi Johnston & Mawson, 1939
Trans. R. Soc. S. Aust. **63** (3), p. 129-30
Holotype ♂, allotype ♀ V1547 from *Petrogale penicillata*
Stomach: collected Upper Burnett R., Qld

Cloacina setonicis Mawson, 1961
Trans. R. Soc. S. Aust. **85**, p. 81-2
Holotype ♂ V2899, allotype ♀ V2900 from *Setonix brachyurus*
Stomach: collected Rottnest Is., W.A.
Paratypes AHC4532

Cloacina similis Johnston & Mawson, 1939
Trans. R. Soc. S. Aust. **63** (3), p. 131
Holotype ♂, allotype ♀ V1549 from *Petrogale penicillata*
Stomach: collected Upper Burnett R., Qld

Cloacina smalesae Mawson, 1975
Trans. R. Soc. S. Aust. **99** (1), p. 39
Holotype ♂, allotype ♀ V1514 from *Macropus eugenii*
Stomach: collected Kangaroo Is., S.A.
Paratypes AHC5605

Cloacina thetidis Johnston & Mawson, 1939
Proc. Linn. Soc. N.S.W. **64** (5-6), p. 532
Proc. Linn. Soc. N.S.W. **65** (5-6), p. 471
Holotype ♀ V2877 from *Macropus thetidis*
Allotype ♂ V1281 from *M. parma*
Stomach: collected New England, N.S.W. and Ourimbah, N.S.W.

Cloacina vestibulata Johnston & Mawson, 1940
Trans. R. Soc. S. Aust. **64** (1), p. 97
Holotype ♀ V1379 from *Macropus melanops*
Stomach: collected Mundalla, S.A.

Cloacina wallabiae Johnston & Mawson, 1939
Proc. Linn. Soc. N.S.W. **64** (5-6), p. 532
Holotype ♂, allotype ♀ V1567 from *Macropus ualabatus*
Stomach: collected Lower Hawkesbury, N.S.W.

Corollostrongylus hypsiprymnodontis Beveridge, 1978
J. Parasit. **64** (4), p. 657-9
Holotype ♂ V1183, allotype ♀ V1184 from *Hypsiprymnodon moschatus*
Intestine: collected Boar Rocket Rd., via Atherton, Qld
Paratype V1185-92

Coronostrongylus coronatus Johnston & Mawson, 1939
Trans. R. Soc. S. Aust. **63** (3), p. 145-6
Holotype ♂ V1560, allotype ♀ V1287 from *Macropus wilcoxi*
Stomach: collected Eidsvold, Qld

Cyclostrongylus alatus Beveridge, 1982
Aust. J. Zool. Suppl. Ser. 83, p. 93-4
Holotype ♂ V1768, allotype ♀ V1769 from *Macropus rufogriseus banksianus*
Oesophagus: collected Swanfels, Qld
Paratypes V1770-9

Cyclostrongylus clelandi Johnston & Mawson, 1939
Proc. Linn. Soc. N.S.W. **64** (5-6), p. 518
now *Alocostoma clelandi* (Johnston & Mawson, 1939) Mawson, 1979
Holotype ♂, allotype ♀ V1696 from *Macropus major*
Oesophagus: collected Coonamble, N.S.W.

Cyclostrongylus dissimilis Johnston & Mawson, 1939
Proc. Linn. Soc. N.S.W. **64** (5-6), p. 519-20
now *Macropostrongyloides dissimilis* (Johnston & Mawson, 1939) Mawson, 1977
Holotype ♂ V2817 from *Macropus ualabatus*
Oesophagus: collected Milson Is., Lower Hawkesbury, N.S.W.
Note: *C. dissimilis* originally described from a single damaged male specimen. Mawson assigned the species to *Macropostrologyloides* after examining fresh material.

Cyclostrongylus elegans Beveridge, 1982
Aust. J. Zool. Suppl. Ser. **83**, p. 97-8
Holotype ♂ V1792, allotype ♀ V1793 from *Macropus parryi*
Oesophagus: collected Rivertree, N.S.W.
Paratypes V1794-03

Cyclostrongylus gallardi Johnston & Mawson, 1939
Proc. Linn. Soc. N.S.W. **64** (5-6), p. 518
Holotype ♂, allotype ♀ V1561 from *Macropus ruficollis*
Oesophagus: collected Ourimbah, Gosford District, N.S.W.

Cyclostrongylus perplexus Beveridge, 1982
Aust. J. Zool. Suppl. Ser. **83**, p. 89-90
Holotype ♂ V1780, allotype ♀ V1781 from *Macropus rufogriseus banksianus*
Oesophagus: collected Grampian Ra., Vic.
Paratypes V1782-91

Cyclostrongylus wallabiae Johnston & Mawson, 1939
Proc. Linn. Soc. N.S.W. **64** (5-6), p. 517-8
Holotype ♂ V2818, allotype ♀ V2819 from *Macropus ualabatus*
Oesophagus: collected Lower Hawkesbury, N.S.W.
Paratypes AHC1672

Foliostoma macropodis Beveridge & Johnson, 1981
Systematic Parasit. **3**, p. 84-5
Holotype ♂ V2027, allotype ♀ V2028 from *Thylogale stigmatica*
Stomach: collected Tolga, Qld
Paratypes V2029-33

Hypodontis thetidis Johnston & Mawson, 1939
Proc. Linn. Soc. N.S.W. **64** (5-6), p. 534
now *Hypodontis macropi* (Johnston & Mawson, 1939) Beveridge, 1979
Holotype ♂ V1214, allotype ♀ V1215 from *Macropus thetidis*
Caecum: collected New England, N.S.W.
Paratypes V1220-3

Labiostrongylus macropodis Johnston & Mawson, 1938
Trans. R. Soc. S. Aust. **62** (2), p. 266-7
Holotype ♀ V2765 from *Macropus robustus*
Stomach: collected Cockatoo Ck., N.T.

Labiostrongylus petrogale Johnston & Mawson, 1938
Trans. R. Soc. S. Aust. **62** (2), p. 270-1
Holotype ♂, allotype ♀ V1367 from *Petrogale lateralis*
Stomach: collected Mt Liebig, N.T.

Macroponema beveridgei Mawson, 1978
Int. J. Parasitol. **8**, p. 164-5
Holotype ♂ V1154, allotype ♀ V1155 from *Macropus antilopinus*
Stomach: collected Elizabeth Downs, N.T.
Paratypes AHC5999

Macroponema comani Mawson, 1978
Int. J. Parasitol. **8**, p. 165-6
Holotype ♂ V1156, allotype ♀ V1157 from *Macropus giganteus*
Stomach: collected Yan Yean, Vic.

Macropicola ocydromi Mawson, 1978
Trans. R. Soc. S. Aust. **102** (4), p. 113-5
Holotype ♂, allotype ♀ V1687 from *Macropus fuliginosus ocydromus*
Large intestine: collected Albany, W.A.

Macropostrongyloides yamagutii Beveridge & Mawson, 1978
Aust. J. Zool. **26**, p. 777-9
Holotype ♂ V1301, allotype ♀ V1302 from *Macropus fuliginosus melanops*
Caecum: collected Pine Plains Stn via Patchewollock, Vic.

Macropostrongylus dissimilis Johnston & Mawson, 1939
Proc. Linn. Soc. N.S.W. **64** (5-6), p. 526
now *Arundelia dissimilis* (Johnston & Mawson, 1939) Mawson, 1977
Holotype ♂, allotype ♀ V1563 from *Macropus ualabatus*
Stomach: collected Lower Hawkesbury, N.S.W.
Note: fresh collections of material from *Wallabia bicolor* (type host) had more visible details of the buccal capsule which allowed Mawson to amend the original description.

Macropostrongylus irma Johnston & Mawson, 1940
Rec. Aust. Mus. **20** (5), p. 363
Holotype ♂ V1671, allotype ♀ V1672 from *Wallabia irma*
Stomach: collected Cranbrook, W.A.
Cotypes AHC1816

Macropostrongylus pearsoni Johnston & Mawson, 1940
Trans. R. Soc. S. Aust. **64** (1), p. 98-9
now *Popovastrongylus pearsoni* (Johnston & Mawson, 1940) Mawson, 1977
Holotype ♂, allotype ♀ V1377 from *Petrogale pearsoni*
Stomach: collected Pearson Is.
Note: The original description was based on two specimens, a male and a female. Additional collections have provided material in better condition so that Mawson was able to prepare a more detailed description.

Macropostrongylus lesouefi Johnston & Mawson, 1939
Proc. Linn. Soc. N.S.W. **64** (5-6), p. 525
Holotype ♂ V2830, allotype ♀ V2831 from *Macropus ruficollis*
Stomach: collected Sydney Zool. Gardens

Macropostrongylus wallabiae Johnston & Mawson, 1939
Proc. Linn. Soc. N.S.W. **64** (5-6), p. 525-6
now *Popovastrongylus wallabiae* (Johnston & Mawson, 1939) Mawson, 1977
Holotype ♂, allotype ♀ V2832 from *Macropus ruficollis*
Stomach: collected Bathurst, N.S.W.

Maplestonema typicum Johnston & Mawson, 1939
Proc. Linn. Soc. N.S.W. **64** (5-6), p. 524
Types V1562 from *Macropus ualabatus*
Stomach: collected Lower Hawkesbury, N.S.W.
Note: Subsequent finding of moulting larvae in new collections of material showed that types are larval stages of a *Cloacina* species. Mawson, pers. comm.

Monilonema lacunosa Beveridge & Johnson, 1981
Systematic Parasit. **3**, p. 80-2
Holotype ♂ V2006, allotype ♀ V2007 from *Thylogale stigmatica*
Stomach: collected Mission Beach, Qld
Paratypes V2008-26

Oesophagonastes leptos Mawson, 1965
Parasit. **55**, p. 159
now *Cyclostrongylus leptos* (Mawson, 1965) Mawson, 1977
Holotype ♂ V1702, allotype ♀ V1703 from *Macropus dorsalis*
Oesophagus: collected Logan Village, Qld
Paratypes AHC6292
Note: Re-examination of type material by Mawson revealed that the type species of *Cyclostrongylus* and *Oesophagonastes* are identical. *Oesophagonastes* thus became a synonym of *Cyclostrongylus*.

Oesophagostomoides longispicularis Beveridge, 1978
Aust. J. Zool. **26**, p. 599-602
Holotype ♂ V1340, allotype ♀ V1339 from *Vombatus ursinus*
Colon: collected Dartmouth, Vic.
Paratypes V1341

Papillostrongylus labiatus Johnston & Mawson, 1939
Trans. R. Soc. S. Aust. **63** (3), p. 143-4
Holotype ♂, allotype ♀ V1559 from *Macropus dorsalis*
Stomach: collected Eidsvold, Qld

Paramacropostrongylus toraliformis Beveridge & Mawson, 1978
Aust. J. Zool. **26**, p. 783-6
Holotype ♂ V1299, allotype ♀ V1300 from *Macropus giganteus*
Caecum: collected Yan Yean, Vic.

Paramacropostrongylus typicus Johnston & Mawson, 1940
Trans. R. Soc. S. Aust. **64** (1), p. 98
Holotype ♂, allotype ♀ V1376 from *Macropus melanops*
Stomach: collected Mundulla, S.A.

Parapharyngostrongylus dentatus Beveridge, 1982
Aust. J. Zool. Suppl. Ser. **83**, p. 46-7
Holotype ♂ V2167, allotype ♀ V2168 from *Macropus dorsalis*
Stomach: collected Emu Park, Qld
Paratypes V2169-78

Pararugopharynx protodemnodontis Magzoub, 1964
Trans. R. Soc. S. Aust. **88**, p. 50-1
Holotype ♂, allotype ♀ V1265 from *Protonemnodon rufogrisea*
Oesophagus and stomach: collected Logan Village, Qld
Paratypes AHC4918

Parazoniolaimus collaris Johnston & Mawson, 1939
Proc. Linn. Soc. N.S.W. **64** (5-6), p. 522-4
Holotype ♂, allotype ♀ V1372 from *Macropus ualabatus*
Stomach: collected Lower Hawkesbury, N.S.W.

Pharyngostrongylus alpha Johnston & Mawson, 1938
Trans. R. Soc. S. Aust. **62** (2), p. 264-6
now *Rugopharynx australis* (Moñnig, 1926) Mawson, 1964
Holotype ♂, allotype ♀ V1365 from *Macropus rufus*
Stomach: collected Mt Liebig, N.T.

Pharyngostrongylus beta Johnston & Mawson, 1938
Trans. R. Soc. S. Aust. **62** (2), p. 266
now *Rugopharynx australis* (Moñnig, 1926) Mawson, 1964
Holotype ♂, allotype ♀ V1366 from *Macropus rufus*
Stomach: collected Mt Liebig, N.T.

Pharyngostrongylus delta Johnston & Mawson, 1939
Trans. R. Soc. S. Aust. **63** (3), p. 136
now *Rugopharynx delta* (Johnston & Mawson, 1939) Yamaguti, 1961
Holotype ♂, allotype ♀ V1553 from *Macropus dorsalis*
Stomach: collected Upper Burnett R., Qld

Pharyngostrongylus dendrolagi Beveridge, 1982
Aust. J. Zool. Suppl. Ser. **83**, p. 31-2
from *Dendrolagus dorianus*
Stomach: collected Lumusa, P.N.G.
Paratypes V1819-20

Pharyngostrongylus diversus Beveridge, 1982
Aust. J. Zool. Suppl. Ser. **83**, p. 22-4
Holotype ♂ V1704, allotype ♀ V1705 from *Macropus parma*
Stomach: collected Niagara Park, N.S.W.
Paratypes V1706-13 & AHC7624

Pharyngostrongylus epsilon Johnston & Mawson, 1939
Trans. R. Soc. S. Aust. **63** (3), p. 137-8
now *Rugopharynx epsilon* (Johnston & Mawson, 1939) Yamaguti, 1961
Holotype ♂, allotype ♀ V1554 from *Macropus dorsalis*
Stomach: collected Eidsvold, Qld

Pharyngostrongylus eta Johnston & Mawson, 1939
Trans. R. Soc. S. Aust. **63** (3), p. 139-40
Holotype ♂, allotype ♀ V1556 from *Macropus* sp.
Stomach: collected Millmerran, Darling Downs, Qld
Paratypes AHC2568

Pharyngostrongylus gamma Johnston & Mawson, 1939
Trans. R. Soc. S. Aust. **63** (3), p. 134-6
Holotype ♂, allotype ♀ V1552 from *Macropus dorsalis*
Stomach: collected Upper Burnett R., Qld

Pharyngostrongylus iota Johnston & Mawson, 1939
Proc. Linn. Soc. N.S.W. **64** (5-6), p. 514-5
Holotype ♂, allotype ♀ V1369 from *Macropus ruficollis*
Stomach: collected Ourimbah, Gosford District, N.S.W.

Pharyngostrongylus kappa Mawson, 1965
Parasitology **55**, p. 147-50
Holotype ♂ V1700, allotype ♀ V1701 from *Macropus canguru*
Stomach: collected Inglewood, Qld

Pharyngostrongylus lambda Mawson, 1965
Parasitology **55**, p. 151-2
Holotype ♂, allotype ♀ V1698-9 from *Macropus robustus*
Stomach: collected Marble Bar, W.A.
Paratypes AHC6289, Syntypes AHC7226

Pharyngostrongylus nelsoni Beveridge, 1982
Aust. J. Zool. Suppl. Ser. **83**, p. 19-22
Holotype ♂ V1726, allotype ♀ V1727 from *Petrogale venustula*
Stomach: collected Mt Borrodaile, N.T.
Paratypes V1728-47

Pharyngostrongylus parma Johnston & Mawson, 1939
Proc. Linn. Soc. N.S.W. **64** (5-6), p. 516

now *Cyclostrongylus parma* (Johnston & Mawson, 1939) Mawson, 1977 from *Macropus parma*
Oesophagus: collected Narara, Gosford District, N.S.W.
Paratypes AHC1827

Pharyngostrongylus papillatus Beveridge, 1982
Aust. J. Zool. Suppl. Ser. **83**, p. 17-9
Holotype ♂ V1714, allotype ♀ V1715 from *Macropus antilopinus*
Stomach: collected 80 km S.W. of Darwin, N.T.
Paratypes V1716-25 & AHC7612

Pharyngostrongylus setosus Beveridge, 1982
Aust. J. Zool. Suppl. Ser. **83**, p. 44-5
Holotype ♂ V1748, allotype ♀ V1749 from *Thylogale stigmatica*
Stomach: collected El Arish, Qld
Paratypes V1750-7

Pharyngostrongylus sharmani Beveridge, 1982
Aust. J. Zool. Suppl. Ser. **83**, p. 32-4
Holotype ♂ V2139, allotype ♀ V2140 from *Macropus bernardus*
Stomach: collected El Sharana, N.T.
Paratypes V2141-60

Pharyngostrongylus theta Johnston & Mawson, 1939
Proc. Linn. Soc. N.S.W. **64** (5-6), p. 514
now *Rugopharynx theta* (Johnston & Mawson, 1939) Yamaguti, 1961
Holotype ♂, allotype ♀ V1368 from *Macropus thetidis*
Stomach: collected New England, N.S.W.

Pharyngostrongylus zeta Johnston & Mawson, 1939
Trans. R. Soc. S. Aust. **63** (3), p. 138-9
now *Rugopharynx zeta* (Johnston & Mawson, 1939) Yamaguti, 1961
Holotype ♂, allotype ♀ V1555 from *Petrogale penicillata*
Stomach: collected Upper Burnett R., Qld

Phascolostrongylus stirtoni Mawson, 1955
Trans. R. Soc. S. Aust. **78**, p. 5-6
now *Oesophagostomoides stirtoni* (Mawson, 1955) Beveridge, 1978 from *Lasiorhinus latifrons*
Colon: collected Blanchetown, S.A.
Syntype ♀ V2812

Popovastrongylus irma, Mawson, 1977
Trans. R. Soc. S. Aust. **101** (2), p. 57-8
Holotype ♂ V1671, allotype ♀ V1672 from *Macropus irma*
Stomach: collected Perth, W.A.

Potorostrongylus finlaysoni Johnston & Mawson, 1939
Trans. R. Soc. S. Aust. **63** (2), p. 308-9
Holotype ♂, allotype ♀ V1374 from *Potorous tridactylus*
Intestine: collected S. Gippsland, Vic.

Potorostrongylus aepyprymnus Mawson, 1974
Trans. R. Soc. S. Aust. **98** (3), p. 137
Holotype ♂ V1692, allotype ♀ V1693 from *Aepyprymnus rufescens*
Stomach: collected Warwick, Qld
Paratypes AHC5811

Rugopharynx omega Beveridge, 1982
Aust. J. Zool. Suppl. Ser. **83**, p. 69-71
Holotype ♂ V1758, allotype ♀ V1759 from *Macropus rufogrieseus banksianus*
Stomach: collected Warwick, Qld
Paratypes V1760-7

Rugopharynx rosemariae Beveridge & Presidente, 1978
Int. J. Parasitol. **8**, p. 379-84
Holotype ♂ V1193, allotype ♀ V1194 from *Macropus giganteus*
Stomach: collected Dartmouth, Vic.
Paratypes V1195-1206

Rugopharynx rufogrisea Magzoub, 1964
Trans. R. Soc. S. Aust. **88**, p. 49-50
Holotype ♂, allotype ♀ V1264 from *Protodemnon rufogrisea*
Stomach: collected Logan Village, Qld
Paratypes AHC4917

Spirostrongylus kartana Mawson, 1955
Trans. R. Soc. S. Aust. **78**, p. 2
now *Cyclostrongylus kartana* (Mawson, 1955) Mawson, 1977
Holotype ♂ V2886, allotype ♀ V2887 from *Macropus eugenii*
Oesophagus: collected Kangaroo Is., S.A.
Paratypes AHC70

Spirostrongylus spirostrongylus Yorke & Maplestone, 1926
Nematode Parasites of Vertebrates, p. 68
from *Macropus agilis*
Oesophagus: Qld, probably Townsville
Syntypes AHC8660

Thylonema arundeli Beveridge, 1981
J. Parasit. **67** (1), p. 103-5
Holotype ♂ V2042, allotype ♀ V2043 from *Thylogale stigmatica*
Stomach: collected El Arish, Qld
Paratypes V2044-55

Thylonema barkeri Beveridge, 1981
J. Parasit. **67** (1), p. 105-7
Holotype ♂ V1982, allotype ♀ V1983 from *Thylogale stigmatica*
Stomach: collected Mission Beach, Qld
Paratypes V1984-93

Thylonema thylonema Beveridge, 1981
J. Parasit **67** (1), p. 101-3
Holotype ♂ V2034, allotype ♀ V2035 from *Thylogale stigmatica*
Stomach: collected Mission Beach, Qld
Paratypes V2036-41

Thylostrongylus parvus Beveridge, 1982
Aust. J. Zool. Suppl. Ser. **83**, p. 53-4
Holotype ♂ V1804, allotype ♀ V1805 from *Thylogale thetis*
Stomach: collected Emu Vale, Qld
Paratypes V1806-15

Thylostrongylus tasmaniensis Beveridge, 1982
Aust. J. Zool. Suppl. Ser. **83**, p. 53-4
Holotype ♂ V2161, allotype ♀ V2162 from *Thylogale billardierii*
Stomach: collected Golconda, Tas.
Paratypes V2163-6

Trigonostonema longibursata Beveridge, 1981
J. Parasit **67** (1), p. 95-7
Holotype ♂ V2059, allotype ♀ V2060 from *Thylogale stigmatica*
Stomach: collected Tolga, Qld
Paratypes V2061-5

Trigonostonema trigonostoma Beveridge, 1981
J. Parasit **67** (1), p. 94-5
Holotype ♂ V2056, allotype ♀ V2057 from *Thylogale stigmatica*
Stomach: collected Mission Beach, Qld
Paratypes V2058

Woodwardostrongylus obendorfi Mawson, 1976
Trans. R. Soc. S. Aust. **100** (3), p. 121-123
Holotype ♂ V1694, allotype ♀ V1695 from *Macropus parryi*
Oesophagus: collected Dorrigo, N.S.W.

Zoniolaimus bancrofti Johnston & Mawson, 1939
Trans. R. Soc. S. Aust. **63** (3), p. 123-4
now *Labiostongylus bancrofti* (Johnston & Mawson, 1939) Kung, 1948
Holotype ♂, allotype ♀ V1541 from *Macropus parryi*
Stomach: collected Eidsvold, Qld

Zoniolaimus bipapillosus Johnston & Mawson, 1939
Trans. R. Soc. S. Aust. **63** (3), p. 125
now *Labiostrongylus bipapillosus* (Johnston & Mawson, 1939) Kung, 1948
Holotype ♂, allotype ♀ V1542 from *Macropus major*
Stomach: collected upper Dawson Valley, Qld

Zoniolaimus clelandi Johnston & Mawson, 1939
Proc. Linn. Soc. N.S.W. **64** (5-6), p. 521
now *Labiostrongylus clelandi* (Johnston & Mawson, 1939) Kung, 1948
Holotype ♂, allotype ♀ V1686
Stomach: collected Lower Hawkesbury, N.S.W.

Zoniolaimus communis Johnston & Mawson, 1939
Trans. R. Soc. S. Aust. **63** (3), p. 125-6
now *Labiostrongylus communis* (Johnston & Mawson, 1939) Kung, 1948
Holotype ♂, allotype ♀ V1543 from *Macropus ualabatus*
Stomach: collected upper Burnett R., Qld

Zoniolaimus insularis Johnston & Mawson, 1939
Trans. R. Soc. S. Aust. **63** (3), p. 126-7
now *Labiostrongylus insularis* (Johnston & Mawson, 1939) Kung, 1948
Holotype ♂, allotype ♀ V1544 from *Macropus welsbyi*
Stomach: collected Stradbroke Is.

Zoniolaimus onychogale Johnston & Mawson, 1939
Trans. R. Soc. S. Aust. **63** (3), p. 128
now *Labiostrongylus onychogale* (Johnston & Mawson, 1939) Kung, 1948
Holotype ♂, allotype ♀ V1546 from *Onychogale frenata*
Stomach: collected Upper Burnett R., Qld

Zoniolaimus ualabatus Johnston & Mawson, 1939
Proc. Linn. Soc. N.S.W. **64** (5-6), p. 521-2
now *Labiostrongylus ualabatus* (Johnston & Mawson, 1939) Kung, 1948
Holotype ♂, allotype ♀ V1614 from *Macropus ualabatus*
Stomach: collected Lower Hawkesbury, N.S.W.

Zoniolaimus uncinatus Johnston & Mawson, 1939
Trans. R. Soc. S. Aust. **63** (3), p. 127-8
now *Labiostrongylus uncinatus* (Johnston & Mawson, 1939) Kung, 1948
Holotype ♂, allotype ♀ V1545 from *Macropus dorsalis*
Stomach: collected Upper Burnett R., Qld

Family Strongyloididae

Parastrongyloides australis Mawson, 1960
Aust. J. Zool. **8** (2), p. 281-2
Holotype ♂, allotype ♀ V1459 from *Isoodon obesulus*
Intestine: collected Cherry Gardens, S.A.

Parastrongyloides peramelis Mackerras, 1959
Aust. J. Zool. **7** (2), p. 99
from *Thylacis obesulus*
Small intestine: collected Mt Glorious, Qld
Paratypes AHC3886

Parastrongyloides trichosuri Mackerras, 1959
Aust. J. Zool. **7** (2) p. 96-9
from *Trichosurus vulpecula*
Small intestine: collected Brisbane, Qld
Paratypes AHC3888

Strongyloides thylacis Mackerras, 1959
Aust. J. Zool. **7** (2), p. 88-96
from *Thylacis obesulus*
Small intestine: collected Brisbane, Qld
Paratypes AHC3887

Superfamily Subuluroidea

Labiobulura baylisi Mawson, 1960
Aust. J. Zool. **8** (2), p. 279-80
Holotype ♂, allotype ♀ V1464 from *Isoodon obesulus*
Alimentary canal: collected Mt Nebo, Qld
Paratypes AHC3285

Labiolulura inglisi Mawson, 1960
Aust. J. Zool. **8** (2), p. 280-1
Holotype ♂, allotype ♀ V1462 from *Isoodon obesulus*
Alimentary canal: collected Cherry Gardens, S.A.
Paratypes AHC3346

Leipoanema ellisi Johnston & Mawson, 1942
Trans. R. Soc. S. Aust. **66** (1), p. 73
Holotype ♂, allotype ♀ V1292 from *Leipoa ocellata*
Intestine: collected Tailem Bend, S.A.
Paratypes AHC146, 308

Subulura clelandi Johnston & Mawson, 1941
Proc. Linn. Soc. N.S.W. **66** (3-4), p. 251
Holotype ♂, allotype ♀ V1430 from *Podargus strigoides*
Intestine: collected Perth, W.A.

Subulura peragale Johnston & Mawson, 1940
Proc. Linn. Soc. N.S.W. **65** (5-6), p. 472-3
now *Labiobulura peragale* (Johnston & Mawson, 1940) Mawson, 1960
Holotype ♂, allotype ♀ V1276 from *Peragale minor*
Stomach: collected MacDonald Downs, N.T.

Superfamily Thelazoidea

Metathelazia naghiensis Spratt, 1980
J. Parasit. **66** (6), p. 1032-35
Holotype ♂ V1821, allotype ♀ V1822 from *Perameles nasuta*
Lung parenchyma: collected Nadgee State Forest, N.S.W.
Paratypes V1823-30

Oxyspirura bancrofti Johnston & Mawson, 1941
Proc. Linn. Soc. N.S.W. **66** (3-4), p. 255
Holotype ♀ 1423 from *Philemon citreogularis*
Orbit: collected Eidsvold, Qld

Rhabdochona jaenschi Johnston & Mawson, 1940
Trans. R. Soc. S. Aust. **64** (2), p. 348
Holotype ♂, allotype ♀ V1390 from *Pseudaphritis urvillei*
Intestine: collected Tailem Bend, S.A.

Thelazia pittae Johnston & Mawson, 1941
Trans. R. Soc. S. Aust. **65** (2), p. 256
Holotype ♂, allotype ♀ V1449 from *Pitta macklotti*
?Orbit: collected North Qld

Superfamily Trichostrongyloidea

Amidostomum biziuriae Johnston & Mawson, 1947
Rec. S. Aust. Mus. **8** (4), p. 551
Holotype ♂ V1259, allotype ♀ V2878 from *Biziura lobata*
Trans. R. Soc. S. Aust. **82**, p. 152-3
Gizzard: collected Tailem Bend and Purnong, S.A.

Amidostomum tribonyx Mawson, 1980
Trans. R. Soc. S. Aust. **104** (1), p. 10-12
Holotype ♂ V1864, allotype ♀ V1865 from *Tribonyx ventralis*
Gizzard: collected Swan Reach, S.A.
Paratypes AHC6833

Amphibiophilus egerniae Johnston & Mawson, 1947
Trans. R. Soc. S. Aust. **71** (1), p. 23 from *Egernia dahli*
Intestine: collected Itari Rocks, Musgrave Ranges, S.A.
Topotype ♂ V2901, ♀ V2902

Amphicephaloides thylogale Beveridge, 1979
Aust. J. Zool. **27**, p. 169-74
Holotype ♂ V1470, allotype ♀ V1471 from *Thylogale billardierii*
Duodenum: collected Launceston, Tas.
Paratypes V1472-80

Asymmetracantha tasmaniensis Mawson, 1960
Aust. J. Zool. **8** (2), p. 273-6
Holotype ♂, allotype ♀ V1460 from *Isoodon obesulus*
Small intestine: collected Dunorlan, Tas.
Paratypes AHC3334

Austroheligmonema magna Mawson, 1961
Aust. J. Zool. **9** (5), p. 815-17
now *Nippostrongylus magnus* (Mawson, 1961) Durette-Desset, 1970
Holotype ♂, allotype ♀ V1330 from *Rattus assimilis*
Intestine: collected Innisfail, Qld
Paratypes AHC3851

Austroheligmonema typicum Mawson, 1961
Aust. J. Zool. **9** (5), p. 815-7
now *Nippostrongylus typicus* (Mawson, 1961) Durette-Desset, 1970
Holotype ♂, allotype ♀ V1329 from *Rattus assimilis*
Intestine: collected Mt Nebo, Qld
Paratypes AHC3852

Austrostrongylus acinocercus Mawson, 1960
Aust. J. Zool. **8** (2), p. 265-7
now *Woolleya acinocercus* (Mawson, 1960) Mawson, 1973
Holotype ♂, allotype ♀ V1463 from *Perameles nasuta*
Intestine: collected Innisfail, Qld
Paratypes AHC3350

Austrostrongylus aggregatus Johnston & Mawson, 1940
Proc. Linn. Soc. N.S.W. **65** (5-6), p. 472
Holotype ♂ V2890, allotype ♀ V2891 from *Macropus ualabatus*
Intestine: collected Milson I., N.S.W.

Austrostrongylus chandleri Mawson, 1973
Trans. R. Soc. S. Aust. **97** (4), p. 262-5
Holotype ♂, allotype ♀ V1516 from *Macropus rufogriseus*
Intestine: collected Bathurst, N.S.W.

Austrostrongylus hydromyos Mawson, 1961
Aust. J. Zool. **9** (5), p. 822-3
now *Woolleya hydromyos* (Mawson, 1961) Mawson, 1973

Holotype ♂, allotype ♀ V1333 from *Hydromys chrysogaster*
Intestine: collected Innisfail, Qld
Paratypes AHC3857

Austrostrongylus hypsiprymnodontis Mawson, 1973
Trans. R. Soc. S. Aust. **97** (4), p. 265
Holotype ♂, allotype ♀ V1517 from *Hypsiprymnodon moschatus*
Intestine: collected Qld
Paratypes AHC5449

Austrostrongylus minutus Johnston & Mawson, 1938
Rec. S. Aust. Mus. **6** (2), p. 195
Holotype ♂, allotype ♀ V26 from *Macropus dorsalis*
Intestine: collected Eidsvold, Qld

Austrostrongylus paratypicus Mawson, 1973
Trans. R. Soc. S. Aust. **97** (4), p. 262
Holotype ♂, allotype ♀ V1515 from *Macropus rufogriseus*
Intestine: collected Bathurst, N.S.W.

Austrostrongylus potoroo Johnston & Mawson, 1949
Trans. R. Soc. S. Aust. **73**, p. 64-5
now *Paraustostrongylus potoroo* (Johnston & Mawson, 1949) Mawson, 1973
Holotype ♂ V2820, allotype ♀ V2821 from *Potorous tridactylus*
Intestine: collected King Is., Tas.
Paratypes AHC7796, 6040

Austrostrongylus thylogale Johnston & Mawson, 1940
Trans. R. Soc. S. Aust. **64** (1), p. 99
Holotype ♂, allotype ♀ V1373 from *Thylogale eugenii*
Intestine: collected Kangaroo Is., S.A.

Austrostrongylus wallabiae Johnston & Mawson, 1939
Proc. Linn. Soc. N.S.W. **64** (5-6), p. 534
Holotype ♂, allotype ♀ V1370 from *Macropus ruficollis*
Intestine: collected Bathurst, N.S.W.

Beveridgiella pearsoni Humphery-Smith, 1980
Bull. Mus. natn. Hist. nat., Paris Ser 4 2 A (4), 1003-6
from *Isoodon macrourus*
Intestine: collected Townsville, Qld
Paratypes V2701

Copemania obendorfi Durette-Desset & Beveridge, 1981
Annal. Parasit. (Paris) **56** (1), p. 63-6
from *Dasyurus maculatus*
Intestine: collected Warrnambool, Vic.
Cotypes V2690, 2691

Dessetostrongylus moorhousei Humphery-Smith, 1980
Bull. Mus. natn. Hist. nat., Paris Ser 4 2 A (4), p. 1007-8
from *Antechinus swainsonii*
Intestine: collected Nadgee, N.S.W.
Paratypes V2702-9

Dessetostrongylus maudii Humphery-Smith, 1980 *Bull. Mus. natn. Hist. Nat.* Paris Ser 4 2 A (4) p. 1008-10
from *Antechinus swainsonii*
Intestine: collected Nadgee, N.S.W.
Paratypes V2710-8

Filarinema peramelis Johnston & Mawson, 1938
Rec. S. Aust. Mus. **6** (2), p. 196-7
now *Mackerrostrongylus peramelis* (Johnston & Mawson, 1938) Mawson, 1960
Holotype ♂, allotype ♀ V27 from *Isoodon obesulus*
Intestine: collected West Burleigh, Qld

Globocephaloides affinis Johnston & Mawson, 1939
Trans. R. Soc. S. Aust. **63** (3), p. 147-8
now *Globocephaloides macropodis* Yorke & Maplestone, 1926 after Beveridge, 1979
Holotype ♀ V1216 from *Macropus dorsalis*
Intestine: collected Eidsvold, Qld
Paratype ♀ V1219

Globocephaloides thetidis Johnston & Mawson, 1939
Proc. Linn. Soc. N.S.W. **64** (5-6), p. 533
now *Globocephaloides macropodis* Yorke & Maplestone, 1926 after Beveridge, 1979
Holotype ♂ V1218, allotype ♀ V1285 from *Thylogale thetis*
Intestine: collected New England, N.S.W.
Note: type material for *Globocephaloides wallabiae* Johnston & Mawson, 1939 is missing, presumed lost. Beveridge (1979) has also put this species as a synonym of *Globocephaloides macropodis* Yorke & Maplestone, 1926.

Heligmonoides emanuelae Mawson, 1961
Aust. J. Zool. **9** (5), p. 809-10
now *Odilia emanuelae* (Mawson, 1961) Durette-Desset, 1973
Holotype ♂, allotype ♀ V1332 from *Rattus conatus*
Intestine: collected Innisfail, Qld

Heligmonoides mackerrasae Mawson, 1961
Aust. J. Zool. **9** (5), p. 808-9
now *Odilia emanuelae* (Mawson, 1961) Durette-Desset, 1973
Holotype ♂ allotype ♀ V1331 from *Melomys cervinipes*
Stomach and intestine: collected Innisfail, Qld
Paratypes AHC3860

Hepatojarakus fasciatus Mawson, 1961
Aust. J. Zool. **9** (5), p. 822
Holotype ♂, allotype ♀ V1335 from *Rattus conatus*
Abdominal mesentery: collected Innisfail, Qld

Hepatojarakus pycnofasciatus Mawson, 1961
Aust. J. Zool. **9** (5), p. 821-2
Holotype ♂, allotype ♀ V1336 from *Rattus assimilis*
Liver and small intestine: collected Innisfail, Qld
Paratypes AHC3856

Ichthostrongylus clelandi Mawson, 1954
Trans. R. Soc. S. Aust. **77**, p. 162-3

Holotype ♂ V2888, allotype ♀ V2889 from *Emissola antarctica*
Spiral valve: collected Encounter Bay, S.A.
Paratypes AHC1412, 8602, 8603

Longistriata brachybursa Mawson, 1961
Aust, J. Zool. **9** (5), p. 805-6
now *Odilia brachybursa* (Mawson, 1961) Durette-Desset, 1973
Holotype ♂, allotype ♀ V1327 from *Melomys cervinipes*
Intestine: collected Innisfail, Qld
Paratypes AHC3862

Longistriata melomyos Mawson, 1961
Aust. J. Zool. **9** (5), p. 801-4
now *Odilia melomyos* (Mawson, 1961) Durette-Desset, 1973
Holoytpe ♂, allotype ♀ V1328 from *Melanomys cervinipes*
Intestine: collected Innisfail, Qld
Paratypes AHC3861

Longistriata polyrhabdote Mawson, 1961
Aust. J. Zool. **9** (5), p. 807
now *Odilia polyrhabdote* (Mawson, 1961) Durette-Desset, 1973
Holotype ♂, allotype ♀ V1325 from *Rattus assimilis*
Intestine: collected Mt Glorious, Qld
Paratypes AHC3854

Longistriata uromyos Mawson, 1961
Aust. J. Zool. **9** (5), p. 804-5
now *Odilia uromyos* (Mawson, 1961) Durette-Desset, 1973
Holotype ♂, allotype ♀ V1326 from *Uromys caudimaculatus*
Intestine: collected Innisfail, Qld
Paratypes AHC3858

Mackerrastrongylus isoodon Durette-Desset & Cassone, 1980
Bull. Mus. natn. Hist. nat. Paris Ser **4** 2 A (4), p. 946-8
Holotype ♂ V2699, allotype ♀ V2700 from *Isoodon macrourus*
Intestine: collected Townsville, Qld

Mastonema melomyos, Mawson, 1961
Aust. J. Zool. **9** (5), p. 818-9
now *Mammanidula melomyos* (Mawson, 1961) Durette-Desset, 1971
Holotype ♂, allotype ♀ V1334 from *Melomys lutillus*
Mammary gland: collected Whyanbeel, Qld
Paratypes AHC3859

Nicollina phascogale Mawson, 1960
Parasitology **50,** p. 425-6
now *Patricialina phascogale* (Mawson, 1960) Inglis, 1968
Holotype ♂, allotype ♀ V1457 from *Phascogale flavipes*
Small intestine: collected Innisfail, Qld
Paratypes AHC3337

Nicollina antechini Beveridge & Barker, 1975
J. Parasitology **V61** (3), p. 489-93
Nasal cavity: collected Powelltown, Vic.
Paratypes V53

Nicollina baylisi Mawson, 1973
Trans. R. Soc. S. Aust. **97** (4), p. 270
Holotype ♂, allotype ♀ V1269 from *Tachyglossus aculeatus*
Small intestine: collected Tas.
Paratypes AHC5459

Nicollina calabyi (Mawson, 1973)
Trans. R. Soc. S. Aust. **97** (4), p. 273
now *Beveridgiella calabyi* (Mawson, 1973) Humphery-Smith, 1980
Holotype ♂, allotype ♀ V1270 from *Myrmecobius fasciatus*
Small intestine: collected W.A.

Nicollina cameroni Thomas, 1959
Trans. R. Soc. S. Aust. **82**, p. 154-5
Holotype ♂ V2873, allotype ♀ V2874 from *Tachyglossus aculeatus*
Small intestine collected Kangaroo Is., S.A.
Paratypes AHC829
Note: This species was described in the only paper in which Mrs Thomas accidentally did not retain use of the name Mawson.

Nicollina inglisi Mawson, 1973
Trans. R. Soc. S. Aust. **97** (4), p. 273
now *Beveridgiella inglisi* (Mawson, 1973) Humphery-Smith, 1980
Holotype ♂, allotype ♀ V1520 from *Myrmecobius fasciatus*
Small intestine: collected W. A.

Nicollina iota Mawson, 1960
Aust. J. Zool. **8** (2), p. 264-5
now *Beveridgiella iota* (Mawson, 1960) Humphery-Smith, 1980
Holotype ♂, allotype ♀ V1465 from *Isoodon obesulus*
Small intestine: collected Dunorlan, Tas.

Nicollina mundayi Mawson, 1973
Trans. R. Soc. S. Aust. **97** (4), p. 270-3
Holotype ♂, allotype ♀ V1519 from *Tachyglossus aculeatus*
Small intestine: collected Tas..
Paratypes AHC58

Oswaldocruzia limnodynastes Johnston & Simpson, 1943
Trans. R. Soc. S. Aust. **66**, p. 172
Holotype ♂, allotype ♀ V1274 from *Limnodynastes dorsalis*
Intestine: collected Adelaide, S.A.
Paratypes AHC2363

Paraustrostrongylus bettongia Mawson, 1973
Trans. R. Soc. S. Aust. **97** (4), p. 267
Holotype ♂, allotype ♀ V1518 from *Bettongia gaimardi*
Intestine: collected Tas.
Paratypes AHC5415

Paraustrostrongylus trichosuri Mawson, 1973
Trans. R. Soc. S. Aust. **97** (4), p. 267-8
Holotype ♂, allotype ♀ V1407 from *Trichosurus vulpecula*
Intestine: collected D'Aiguillar, Qld.
Paratypes AHC5443

Paraustrostrongylus ratti Obendorf, 1979
Aust. J. Zool. **27** (2), p. 867-9
Holotype ♂ V810, allotype ♀ V811 from *Rattus fuscipes*
Intestine: collected Gladysvale, Vic.
Paratypes V812-3

Patricialina birdi Humphery-Smith & Durette Desset, 1981
Bull. Mus. natn. Hist. nat., Paris, Ser **4.** 3 A (1), p. 128-30.
Holotype ♂ V2721, allotype ♀ V2722 from *Antechinus swainsonii*
Intestine: collected Nadgee, N.S.W.

Peramelistrongylus skedastos Mawson, 1960
Aust. J. Zool. **8** (2), p. 268-71
Holotype ♂, allotype ♀ V1461 from *Isoodon obesulus*
Stomach and intestine: collected Innisfail, Qld.

Profilarinema hemsleyi Durette-Desset & Beveridge, 1981
Ann. Parasit. (Paris) **56** (2), p. 188-91
from *Trichosurus vulpecula*
Stomach: collected W.A.
Cotypes V2694-8

Sprattellus harrigani Durette-Desset & Cassone, 1980
Bull. Mus. natn. Hist. nat., Paris Ser **4** 2 A (4), p. 949-51
from *Phascogale tapoatafa*
Intestine: collected Vic.
Cotypes V2694-8

Sprattellus woolleyae Durette-Desset & Cassone, 1980
Bull. Mus. natn. Hist. nat., Paris Ser **4** 2 A (4), p. 951-53
from *Antechinus stuartii*
Intestine: collected Sandy Point, Western Point, Vic.
Cotypes V2692-3

Tetrabothriostrongylus mackerrasae Mawson, 1960
Parasitology **50**, p. 427-8
Holotype ♂, allotype ♀ V1458 from *Phascogale flavipes*
Intestine: collected Innisfail, Qld.
Paratypes HC3340

Trichostrongylus (s.l.) incertus Johnston & Mawson, 1941
Trans. R. Soc. S. Aust. **65** (2), p. 254-5
Holotype ♂ V1448 from *Hydroprogne caspia strenua*
Intestine: collected Tailem Bend, S.A.

Woolleya antechini Humphery-Smith & Durrette-Desset (in press)
Holotype ♂ V2723, allotype ♀ V2724 from *Antechinus stuartii*
Intestine: collected Powelltown, Vic.

Woolleya didelphis Humphery-Smith & Durette-Desset (in press)
Holotype ♂ V2728, allotype ♀ V2729 from *Antechinus swainsonii*
Intestine: collected Nadgee, N.S.W.

Woolleya hickmani Mawson, 1973
Trans. R. Soc. S. Aust. **97** (4), p. 277-8
now *Patricialina hickmani* (Mawson, 1973), Humphery-Smith & Durette-Desset, 1981
Holotype ♂, allotype ♀ V1523 from *Antechinus stuartii*
Intestine: collected Condor Ck., A.C.T.

Woolleya martini Mawson, 1973
Trans. R. Soc. S. Aust. **97** (4), p. 275
now *Patricialina martini* (Mawson, 1973) Humphery-Smith & Durette-Desset, 1981
Holotype ♂, allotype ♀ V1522 from *Antechinomys spenceri*
Intestine: collected Sandringham, Qld.
Paratypes AHC7295

Woolleya monodelphis Mawson, 1973
Trans. R. Soc. S. Aust. **97** (4), p. 278-9
Holotype ♂, allotype ♀ V1524 from *Antechinus stuartii*
Intestine: collected Condor Ck., A.C.T.

Woolleya sprenti Mawson, 1973
Trans. R. Soc. S. Aust. **97** (4), p. 275
Holotype ♂, allotype ♀ V1521 from *Dasyurus viverrinus*
Intestine: collected Icena, Tas.
Paratypes AHC5447, 4940

Superfamily Trichuroidea

Anatrichosoma haycocki Spratt (in press)
Holotype ♂ V2859, allotype ♀ V2860 from *Antechinus swainsonii*
Paracloacal glands: collected Nadgee State Forest, N.S.W.
Paratypes V2861-69

Capillaria cooperi Johnston & Mawson, 1945
Trans. R. Soc. S. Aust. **69** (2), p. 245
Holotype ♂ V1230, allotype ♀ V1231 from *Callionymus calauropomus*
Alimentary canal: collected St Vincent's Gulf, S.A.

Capillaria ellisi Johnston & Mawson, 1945
Trans. R. Soc. S. Aust. **69** (2), p. 247
Holotype ♂ V1237, allotype ♀ V1238 from *Chenopsis atrata*
Alimentary canal: collected Tailem Bend, S.A.

Capillaria graucalina Johnston & Mawson, 1941
Proc. Linn. Soc. N.S.W. **66** (3-4), p. 250
Holotype ♂, allotype ♀ V1431 from *Coracina novaehollandiae*
Alimentary canal: collected West Burleigh, Qld

Capillaria grallinae Johnston & Mawson, 1945
Trans. R. Soc. S. Aust. **69** (2), p. 247-8
Holotype ♂ V1235, allotype ♀ V1236 from *Grallina cyanoleuca*
Alimentary canal: collected Tailem Bend, S.A.

Capillaria jaenschi Johnston & Mawson, 1945
Trans. R. Soc. S. Aust. **69** (2), p. 245
Holotype ♂ V1240, allotype ♀ V1241 from *Phalacrocorax sulcirostris*
Alimentary canal: collected Tailem Bend, S.A.

Capillaria latridopsis Johnston & Mawson, 1945
Trans. R. Soc. S. Aust. **69** (2), p. 245
Holotype ♂ V1227, allotype ♀ V1228 from *Latridopsis forsteri*
Alimentary canal: Kangaroo Is., S.A.

Capillaria lepidopodis Johnston & Mawson, 1944
Trans. R. Soc. S. Aust. **68** (1), p. 66
Holotype ♀ V1229 from *Lepidopus caudatus*
Alimentary canal: collected St Vincents Gulf, S.A.

Capillaria miniopterae Thomas, 1959
Trans. R. Soc. S. Aust. **82**, p. 151-2
Holotype ♂ V2809, allotype ♀ V2810 from *Miniopterus blepotis*
Alimentary canal: collected Canungra, Qld
Paratypes AHC3155
Note: The description of this species was published in the only paper in which Mrs Thomas did not retain use of the name Mawson.

Capillaria murrayensis Johnston & Mawson, 1940
Trans. R. Soc. S. Aust. **64** (2), p. 342
Holotype ♀ V1387 from *Mccullochella macquariensis*
Intestine: collected from Tailem Bend, S.A.

Capillaria orectolobi Johnston & Mawson, 1951
Trans. R. Soc. S. Aust. **74** (1), p. 24
Holotype ♂ V2879 from *Orectolobus devisi*
Alimentary canal: collected Port Willunga, S.A.
Paratypes AHC8662

Capillaria plectroplites Johnston & Mawson, 1940
Trans. R. Soc. S. Aust. **64** (2), p. 341-2
Holotype ♂, allotype ♀ V1386 from *Plectroplites ambiguus*
Gills: collected Swan Reach, S.A.

Capillaria pomatostomi Johnston & Mawson, 1945
Trans. R. Soc. S. Aust. **69** (2), p. 247
Holotype ♀ V1239 from *Pomatostomus superciliosus*
Alimentary canal: collected Tailem Bend, S.A.

Capillaria praeputialis Obendorf, 1979
Aust. J. Zool. **27**, p. 872-7
Holotype ♂ V806, allotype ♀ V807 from *Rattus fascipes*
Praeputial glands: collected Gladysdale, Vic.
Paratypes V808-9

Capillaria recurvirostrae Mawson, 1966
Parasitology **56**, p. 282
Holotype ♂, allotype ♀ V1466 from *Recurvirostra novaehollandiae*
Duodenum: collected St Kilda, Vic.

Capillaria rhinobati Johnston & Mawson, 1945
Trans. R. Soc. S. Aust. **69** (2), p. 243-4
Holotype ♂ V1232, allotype ♀ V1233 from *Aptychotrema banksii*
Alimentary canal: collected Rapid Bay, S.A.

Capillaria rickardi Beveridge & Barker, 1975
J. Helminth. **49**, p. 219-220
Holotype ♂ V64, allotype ♀ V65 from *Antechinus stuartii*
Stomach: collected Powelltown, Vic.
Paratypes V66

Capillaria strigis Johnston & Mawson, 1944
Trans. R. Soc. S. Aust. **68** (1), p. 65-6
Holotype ♂ V1234 from *Ninox novaeseelandiae*
Alimentary canal: collected Invercargill, N.Z.

Capillaria tandani Johnston & Mawson, 1940
Trans. R. Soc. S. Aust. **64** (2), p. 342
Holotype ♀ V1388 from *Tandanus tandanus*
Intestine: collected Tailem Bend, S.A.

Capillaria thomascameroni Mawson, 1969
J. Fish. Res. Board Canada, **26**, p. 1104-5
Holotype ♂, allotype ♀ V1509 from *Larus novaehollandiae*
Oesophagus, proventiculus: collected West Is., S.A.

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Thelandros; Oxyuroidea 396
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Thoracostoma; Enoplidae 386
Thylonema; Strongyloidea 403
Thylostrongylus; Strongyloidea 404
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REPRODUCTIVE BIOLOGY OF THE FROGS OF THE MAGELA CREEK SYSTEM, NORTHERN TERRITORY

by

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ABSTRACT

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The Magela Creek system occupies the eastern fringe of the Northern Territory floodplain, and the adjacent escarpment country. Twenty-four species of frogs occupy this area.

We have examined facets of the reproductive biology of the frog fauna over two entire wet seasons. Data are recorded on the onset, duration and termination of activity, calling and breeding, and are correlated with temperature and relative humidity. Most species breed at the onset of the wet season before the floodplain is completely inundated.

For each species the eggs and form of the spawn clump are described. Developmental history is derived from laboratory observations on spawn transported to Adelaide. Tadpoles are described and illustrated at various stages of their development, and growth curves are plotted.

Details of observations on activity are recorded. Several species bask in the sun and attain body temperatures of up to 36.4°C.

Fecundity and reproductive modes are plotted. We note limited reproductive diversity and high selective advantage in abbreviation of the developmental span.

Introduction

Very few studies have been undertaken in Australia on diverse anuran communities. With the exceptions of the unpublished observations of Straughan (1966) in eastern Queensland, and Humphries' (1979) study near Canberra, A.C.T., emphasis to date has centred upon interaction between particular congeneric components within communities.

With the support of the Supervising Scientist for the Alligator Rivers Region we undertook a study of the frog fauna of a portion of the floodplains and adjacent escarpment in the Northern Territory from October 1978 to April 1979 and October 1979 to March 1980. (Tyler and Crook, 1980).

The principal objectives of the study were to determine which species were likely to colonise the uranium mining sites there (in particular the retention ponds and tailings dams) and, further, the nature of skeletal abnormalities in the populations. Such data would permit an assessment to be made of the value of frogs as indicator organisms for monitoring the long-term impact of uranium mining.

At the commencement of the study six of the species now known to occur at the site were undescribed, and so our early efforts concentrated upon establishing the composition of the fauna. Similarly the spawn and tadpoles of 21 of the 24 species were unknown. In consequence we were obliged to concentrate activities upon fundamental descriptive studies of life histories, and it was neither possible nor a component of the contract to examine community structures in any detail.

Because the study site included floodplain and escarpment, it embraced the two extremes of habitat that occur in the northern portion of the Northern Territory, and potentially at least appeared to permit extrapolation of results to more distant areas.

The study area experiences striking climatic extremes with marked winter dry seasons, and summer wet seasons. Here we describe the reproductive habits of the frog fauna, describe the embryonic and larval morphology and examine the reproductive regimes in an area where most species have a limited breeding season.

Description of Study Site

Magela Creek is a tributary of the East Alligator River, Northern Territory, located approximately 230 km east of Darwin (Fig. 1). Magela Creek drains the western periphery of the Arnhemland Plateau, and the adjacent, low-lying floodplain, and flows only in the wet season. The term 'Magela Creek system' is used to embrace the drainage area, which represents an interface of ecologically divergent zones.

Our studies were centred at the Ranger uranium mining site at Jabiru located at 24.5 m above sea level. The majority of our observations were made within a 30-km radius, with the extreme of that range being north towards the East Alligator River (Fig. 1).

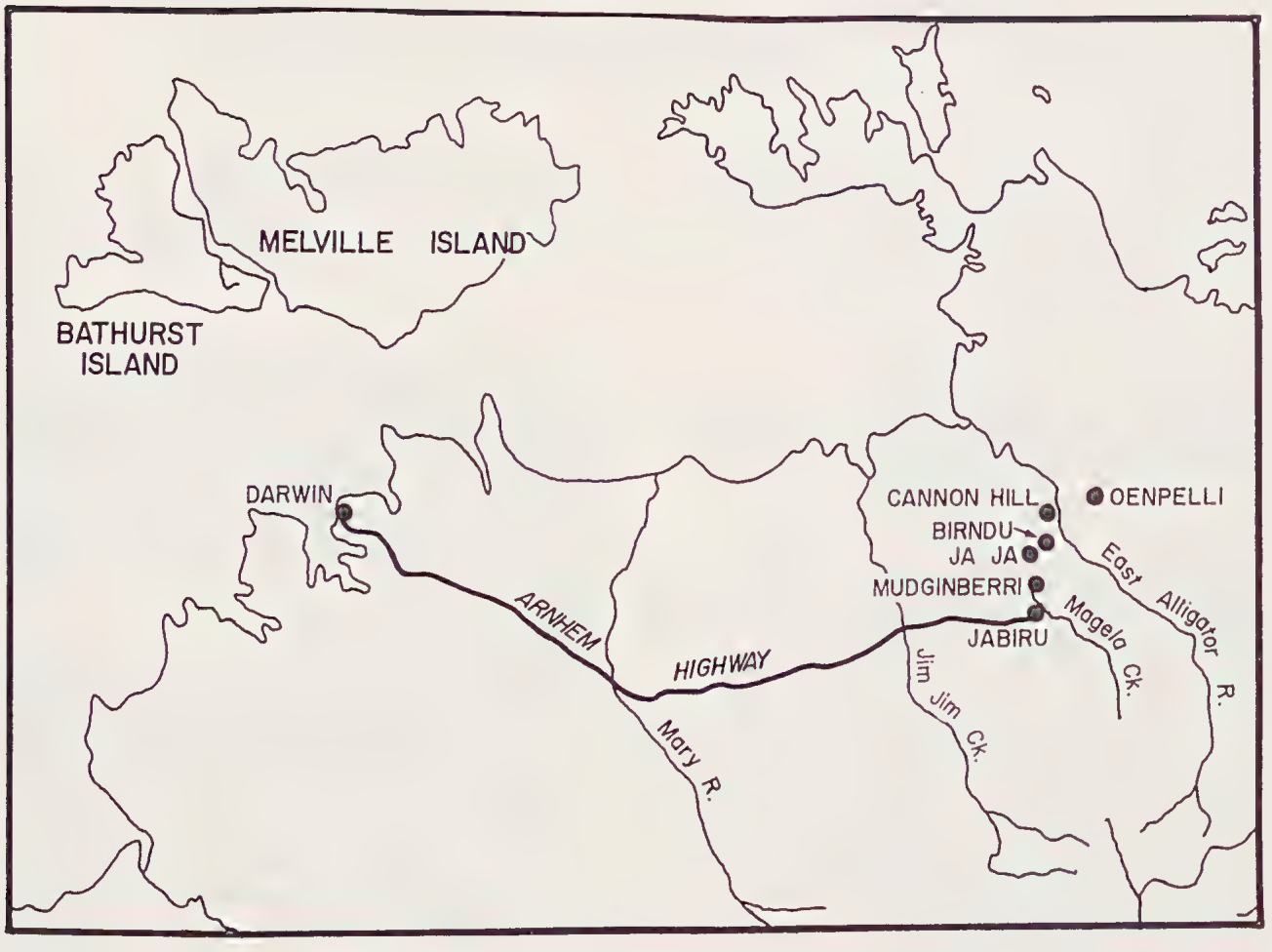

FIG. 1. Study site within the Magela Creek System, Northern Territory.

The soils are diverse, but their significance as a factor influencing frog distribution is associated with porosity, and the extent to which they can be penetrated by the fossorial species.

There is a lack of uniformity in the nomenclature and delineation of plant communities in the area surrounding Magela Creek (Christian & Aldrick, 1977; Williams, 1979). The system that we have adopted is applicable to frog communities, and involves the following seven units, each of which is meaningful in an ecological sense, and significant in the diversity and chronological sequence of breeding sites occurring there. Data on dominant plant species within the units are from Christian & Aldrick (1977).

1. Sandstone scrub and woodland in escarpment

The breeding sites on the escarpment vary from pools on the open rock face (Fig. 2A) to streams through deep crevices in the sandstone. Tadpoles have been found in shallow depressions on exposed rock faces, where the water temperatures reach up to 45°C, and where there is little aquatic algal growth. The pools fill with rainwater early in the wet season, and are then used as breeding sites. Further storms cause overflowing, and water runs over the rocks and into small, scrub-lined streams which flow only during these storms. For the remainder of the time the stream beds are a series of shallow, isolated pools among sandstone rocks with spinifex, sedges and wiry grasses along the banks. The streams extend into deeper, sandy-floored streams (eroded from the sandstone), which persist for much longer after the wet season has ended. The narrow gorges created by these streams are often very deep and have vertical faces. There is low light intensity and the water is cold (<10°C). The larger streams support a woodland including *Eucalyptus dichromophloia, E. phoenicea,* and *E. miniata,* smaller trees *Owenia, Xanthostemon* and *Erythrophloeum* with wiry grasses and spinifex in the understorey.

2. Sandstone rainforest remnants

These relict forests differ from the woodlands through the domination of an undescribed myrtaceous evergreen tree species up to 22 m high. Other non-eucalypt trees are present; the understorey is sparse, and the leaf litter is thick and moist. Such forests occur in the broken terrain or sandstone plateau and escarpment, usually in narrow gorges at the base of the escarpment. The streams usually have defined channels with rocky bottoms, and are permanent (Fig. 2B). Frogs utilize the pools in small side streams which flow only after storms.

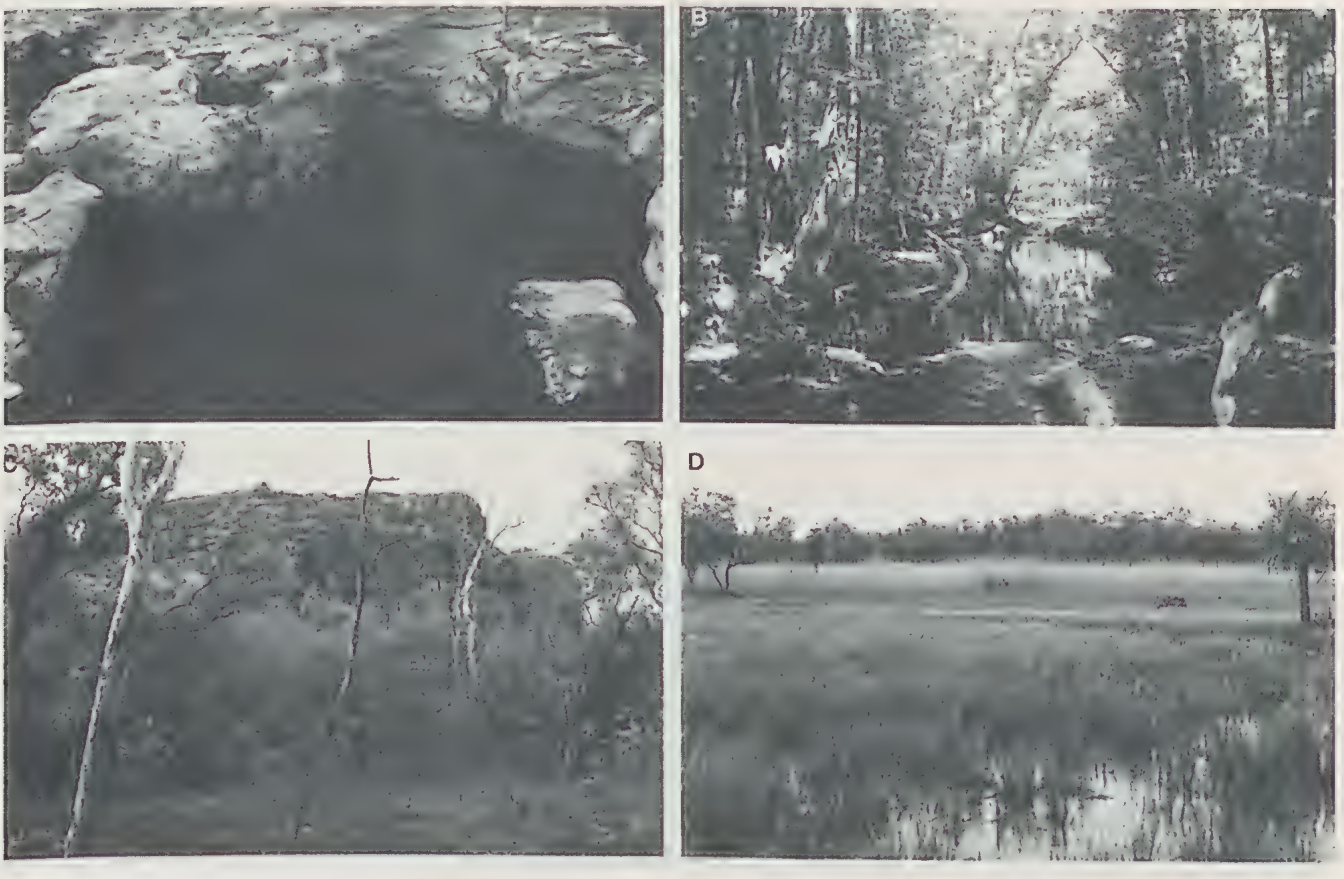

FIG. 2. Habitat types: *(a)* Pool on rockface in sandstone escarpment, Birndu; *(b)* Remnant rainforest, Radon Creek; *(c)* Open sclerophyll forest at foot of escarpment, Birndu; *(d)* Inundated grassland.

3. Open sclerophyll forest

The open forest is dominated by *Eucalyptus tetrodonta* and *E. miniata* with the occasional *Erythrophloeum*. The understorey is varied including *Livistona, Xanthostemon, Planchonia, Buchanania, Grevillea, Melaleuca* and *Acacia*. Annual and perennial grasses are also present (Fig. 2C). In the wet season shallow depressions in this woodland provide breeding sites for several frog species. Heavy storms inundate the whole forest floor, so creating many microhabitats in which frogs abound.

4. Inundated grasslands

In the open sclerophyll forest and along the creeks are large areas predominated by annual and perennial grasses (Fig. 2D). These areas have sandy soil, and any depressions fill with water early in the wet season providing breeding sites for several frog species. Inundation of these areas occurs once the wet season has set in (usually in early January). More frog species then utilize the areas of shallow water outside the deeper depressions.

5. Fringes of billabongs

The main body of water of the billabongs is not a significant habitat for frogs. Of greater significance are the pools and grassy areas on the fringes among the *Melaleuca* and *Pandanus* (Fig. 3A). These areas fill with water early in the wet season and predatory fishes are excluded for long enough for tadpoles to complete metamorphosis.

6. Floodplains

These are large expanses of sedgeland which are inundated for two to six months of the year (Fig. 3B). The principal plant genera there are *Cyperus, Scirpus, Eleocharis, Fairena* and *Sesbania* with some grasses. A wide variety of herbaceous plants and water lilies occur in areas where there is inundation for six to eight months. The frogs usually inhabit the edges of the floodplains, and occupy small islands of rock and vegetation when the floodplains are inundated.

7. Artificial pools, borrow pits, ponds etc.

Buffalo wallows are important breeding sites on the floodplains and inundated grasslands in the early months of the wet season. Man-made borrow pits beside the roads are important throughout the wet season, providing shallow temporary pools in areas where such pools would not occur naturally (Tyler, 1979). The soil is gravelly and the vegetation is sparse.

FIG. 3. Habitat types: *(a)* Billabong fringe; *(b)* Floodplain from the air; *(c)* Jabiru airstrip with temporary pools; *(d)* Retention Pond No. 2.

The large cleared areas around the pools provide a larger number of potential calling sites for males than the surrounding open forest. Dams, drainage ditches and even pools on the road surface are used as breeding sites by some species (Fig. 3C). Indeed any disturbance of the environment causing the formation of pools increases the breeding potential of frogs in the area, and tailings dams, retention ponds, siltation pools and other earthworks have to be considered in a similar sense (Fig. 3D).

The rainfall follows a distinct seasonal pattern. There is a wet season generally heralded in late October with occasional showers in the late afternoon or evening, but the greatest volume of rain occurs from December to March. The maximum rainfall recorded at Jabiru Airstrip in one month since 1971 is 767.9 mm in February 1980. Annual totals there range from 1121 mm to 2282 mm. As indicated above, during the study the 1979-80 period was atypical because there was no rain from June to September, followed by a late onset of the wet season and then the record February falls, leading ultimately to the second highest annual total.

Shade temperature maxima and minima were 39.9°C in October 1979 and 14.1°C in August 1979. Mean monthly maxima and minima at Jabiru Airstrip during the study period are depicted in Figure 4.

During the study period there was substantial alteration to the structure of the site and hence to the area in which we undertook observations. Principal changes affecting frog breeding sites were the completion of construction and the filling of the retention ponds and the tailings dam, so increasing the area of static water by more than 1 km², and the grading of the airstrip which eliminated numerous shallow pools.

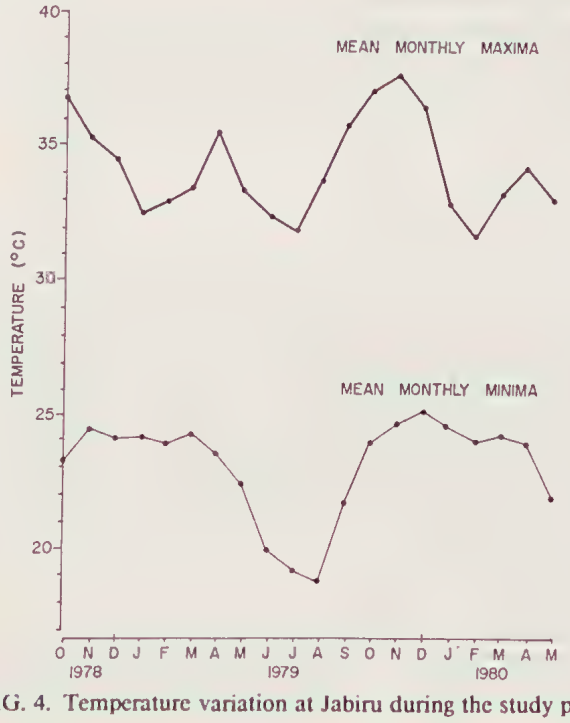

FIG. 4. Temperature variation at Jabiru during the study period.

Methods

Field observations were undertaken during the wet seasons by G. A. Crook. He resided at Jabiru from October 1978 to April 1979, and from October 1979 to March 1980. M. J. Tyler visited the study area in November-December 1977, November 1978, February 1979, October 1979, November-December 1979, and February 1980. Supplementary field assistance was provided on various occasions by M. Davies, A. A. Martin and J. Brooks.

Initially the field programme concentrated upon establishing the nature of the fauna, leading to the collection of 24 species, of which six were hitherto undescribed. Biological data recorded included surface activity, calling activity of males, spawning, the physical form of spawn clumps, and the physical appearance of the tadpoles. Water temperatures at breeding sites were recorded with a Wesco rapid-reading thermometer (reading 0-50°C) and relative humidity measured with a Zeal Whirling Psychrometer.

Spawn and tadpoles were obtained at night and transported to Adelaide by air in insulated containers. Upon arrival at the University of Adelaide the specimens were transferred to a constant temperature laboratory maintained at 30° ±0.5°C. Spawn and small quantities of tadpoles were transferred to white 'Advance' plastic containers of 1L capacity. Denser aggregations were maintained in 5L capacity all-glass aquaria. The cultures were aerated sufficiently to elevate oxygen levels, without reducing the water temperature.

Water was changed daily. The water used was passed through a commercial softener and filter, followed by passage through an activated carbon dechlorinator and a bacterial filter. Water was allowed to stand in the plastic containers or glass aquaria for 24 hours prior to use to equilibrate to room temperature. The light regime of the room was controlled and seasonally adjusted to that at Jabiru.

Tadpoles were fed on washed and boiled lettuce leaves. Tadpoles were sampled regularly and preserved in Tyler's (1962) tadpole fixative. Selection of specimens for preservation followed the attainment of the progressive developmental stages of Gosner (1960). Subsequently specimens were measured with a microscope eyepiece micrometer or dial callipers to an accuracy of 0.01 mm.

A representative collection of the species studied has been deposited in the South Australian Museum.

IDENTIFICATION OF SPECIES

Species Composition

Three families of frogs occur in the Magela Creek system. They represent the Hylidae (2 genera, 16 species), Leptodactylidae (5 genera, 7 species) and Microhylidae (1 genus, 1 species); a total of 24 species. Of that total only two species: *Litoria personata* Tyler, Davies & Martin and *Uperoleia arenicola* Tyler, Davies & Martin are currently known only from that area. Most of the remainder are widely distributed across northern Australia.

Distribution and Abundance

In Table 1 we have plotted the species composition of the fauna, together with our assessment of relative abundance based on the frequency with which representatives were encountered. 'Absent' indicates our failure to observe or hear a species in a particular area during the entire study; 'Rare' includes 1-10 observations; 'Common' involves at least 25 sightings, whereas 'Abundant' indicates the presence of a species in large numbers on any night within the period that we found the species to be active.

Identification

To permit identification in the field we have prepared dichotomous keys to spawn, tadpoles and adults. To assist the identification procedures we have divided the total fauna into two groups—the species found on the escarpment, and those found elsewhere (which we term 'lowland' for want of a more appropriate all-embracing word). Within the 'escarpment' category we have included species such as *Limnodynastes ornatus* and *L. convexiusculus*, which are in no way adapted to that environment, but occasionally they penetrate its fringe.

Excellent colour photographs of many of the species appear in handbooks of the frogs of Australia by Barker and Grigg (1977) and by Cogger (1979). However, because there are so many additional species not included in those publications, and confusion about the use of some names, we recommend that their photographs be used to confirm identifications reached here, rather than as primary identification sources.

(a) KEY TO FROG EGGS FOUND UPON THE ESCARPMENT

1. Spawn terrestrial, laid in leaf litter . . . *Sphenophryne robusta*
   Spawn laid in water 2
2. Spawn in form of foam nest 3
   Spawn not in form of foam nest 5
3. Eggs slightly pigmented, or unpigmented; foam nest deposited in concealed sites; foam persists for several days 4
   Eggs black with white vegetal pole, foam nest floating on surface of pools; foam nest collapses within six hours . . . . . *Limnodynastes ornatus*

TABLE 1: DISTRIBUTION AND ABUNDANCE OF THE FROG FAUNA OF THE MAGELA CREEK AREA.

0 Absent 1 Rare 2 Common 3 Abundant	Escarpment: Sandstone scrub and woodland	Escarpment: Rainforest remnants	Inundated grassland	Open Sclerophyll Forest	Billabong Fringes	Floodplains	Artificial pools, borrow pits, scrapes etc.
Litoria bicolor	0	0	2	0	3	2	0
L. caerulea	2	2	1	1	1	1	0
L. coplandi	3	2	0	0	0	0	0
L. dahlii	0	0	1	0	2	3	1
L. inermis	0	0	1	0	2	0	3
L. sp. nr. *latopalmata*	0	0	3	0	2	1	3
L. meiriana	3	3	0	0	0	0	0
L. microbelos	0	0	1	0	3	2	0
L. nasuta	0	0	3	2	2	0	1
L. personata	2	0	0	0	0	0	0
L. rothii	0	0	2	1	2	2	2
L. rubella	0	0	2	1	2	2	3
L. tornieri	0	0	3	0	2	1	3
L. wotjulumensis	2	2	1	0	0	0	2
Cyclorana australis	0	0	2	1	2	2	3
C. longipes	0	0	1	0	1	1	3
Limnodynastes convexiusculus	1	0	2	0	2	3	0
L. ornatus	2	0	2	1	0	0	3
Notaden melanoscaphus	0	0	3	3	0	0	0
Megistolotis lignarius	2	2	0	0	0	0	0
Ranidella bilingua	0	0	3	1	2	2	0
Uperoleia arenicola	1	0	0	0	0	0	0
Uperoleia inundata	0	0	3	2	0	0	0
Sphenophryne robusta	0	2	0	0	2	0	0

4. Foam nest under boulders in streambeds or pools; eggs creamy yellow ..... *Megistolotis lignarius*
   Foam nest in small hollows among grass tussocks; eggs white ..... *Limnodynastes convexiusculus*
5. Large number of brown/white eggs laid as surface film ..... *Litoria caerulea*
   Eggs laid singly or in small clumps 6
6. Spawn floating on surface ..... *L. wotjulumensis*
   Spawn below surface of water 7
7. Spawn laid as small clumps or film firmly attached to sandstone rock face ..... *L. meiriana*
   Spawn laid as single eggs or in small clumps on bottom of rock pools ..... *L. coplandi*

The spawn of *Uperoleia arenicola* and *Litoria personata* is unknown.

(b) KEY TO TADPOLES FOUND UPON THE ESCARPMENT

1. With distinctive gold or yellow dorso-lateral stripes ..... *L. personata*
   Lacking gold or yellow dorso-lateral stripes 2
2. Body flattened dorso-laterally, eyes dorsal, narrowly separated. Papillary border widely separated superiorly ..... *Limnodynastes ornatus*
   Body not flattened dorso-laterally, eyes dorso-lateral 3
3. Black colour 4
   Brown colour 5
4. Papillary border narrowly separated superiorly; small papillae; 4/3, 5/3, 6/3 labial tooth rows; strong horny beak ..... *Megistolotis lignarius*
   Papillary border widely separated superiorly; large papillae; 5/3 labial tooth rows; horny beak weakly developed ..... *Limnodynastes convexiusculus*
5. Dark brown; conspicuous white patch near base of abdomen ..... *Litoria coplandi*
   Lacking white patch near base of abdomen 6
6. Papillary border widely separated superiorly; horny beak rather weakly developed. Tail fin lightly pigmented; tail muscle pigmentation in two stripes: one lateral halfway along tail, one along dorsal edge ..... *Litoria caerulea*
   Horny beak strongly developed. Upper tail fin pigmented. Tail muscle heavily pigmented 7
7. Tadpoles small (<26 mm); papillary border narrowly separated superiorly. Ventral surface dark, becoming lighter. Dark brown stripe along dorsal edge of tail muscle ..... *L. meiriana*
   Tadpoles medium-sized (<45 mm); papillary border separated superiorly. Ventral surface light from stage 26 ..... *L. wotjulumensis*

It is assumed that *Sphenophryne robusta* has no free-swimming tadpole.

(c) KEY TO ADULT FROGS FOUND UPON THE ESCARPMENT

1. Green or olive; large (up to 110 mm); expanded discs on toes, conspicuous toe webbing ..... *Litoria caerulea*
   Not green or olive 2
2. Tympanum not visible 3
   Tympanum distinctly visible 6
3. Very small (up to 25 mm length) 4
   Size within range of 25-75 mm 5
4. Brown with dark stripe on side of head sometimes extending along sides; cylindrical toe discs. Found in leaf litter only ..... *Sphenophryne robusta*
   Brown to slate grey with orange parotoid glands; no toe discs. Metatarsal tubercle enlarged. Found in sand streambeds ..... *Uperoleia arenicola*
5. Inner metatarsal tubercle enlarged; usually sandy with darker back patterns, rounded snout; <45 mm in length. Slight web on toes ..... *Limnodynastes ornatus*
   Inner metatarsal tubercle not enlarged; grey or brown with dark mottling on dorsum, slightly elongate snout; up to 65 mm in length. Conspicuous cream supralabial gland. No webbing ..... *L. convexiusculus*
6. Robust; large, prominent, oval inner, but no outer metatarsal tubercle. Toe discs absent. Hindlimbs short; males have black nuptial spines ..... *Megistolotis lignarius*
   Not robust; no large, prominent, oval inner metatarsal tubercle. Toe discs present. Long hindlimbs 7

7. Feet with trace of webbing. Small (<35 mm). Conspicuous head stripe. Toe disc expanded ..... *Litoria personata*
Hindlimbs with conspicuous webbing 8
8. Conspicuous head stripe finishing midway along body, toe discs small. Large size (up to 70 mm SV length) ..... *L. wotjulumensis*
Toe discs well developed. No head stripe 9
9. Small (<25 mm), diurnal and nocturnal. Heavy mottled dark brown band on legs, dorsal pattern ..... *L. meiriana*
Up to 40 mm, nocturnal. Mottled dorsal pattern, large inner metatarsal tubercle ..... *L. coplandi*

(d) KEY TO LOWLAND FROG EGGS

1. Terrestrial, found in leaf litter in *Melaleuca* swamps ..... *Sphenophryne robusta*
Deposited in water 2
2. Deposited in foam nest 3
Not deposited in foam nest 4
3. Barely pigmented; foam nest in concealed areas in inundated grassland; foam persists for several days *Limnodynastes convexiusculus*
Black with white vegetal pole; foam nest conspicuous, floating on surface of pools; foam nest collapses within six hours ..... *L. ornatus*
4. In large loosely attached clumps on bottom of pools 5
Not in large loosely attached clumps 6
5. Brown, ovidiameter 1.2-1.5 mm; capsule diameter 1.9-2.5 mm ..... *Cyclorana longipes*
Brown, ovidiameter 1.3-1.6 mm; capsule diameter 2.5-2.8 mm ..... *C. australis*
6. Laid singly or in small clumps on bottom of pools in inundated grassland ..... *Uperoleia inundata*
Not laid singly or in small clumps on bottom of pools in inundated grassland 7
7. Laid as free-floating clumps 8
Not laid as free-floating clumps 10
8. Capsule large (6.1 mm); brown and white egg; three jelly envelopes ..... *Litoria inermis*
Capsule medium (4.5-5.5 mm); dark brown and white egg 9
9. Ovum diameter 1.6-1.9 mm ..... *L. wotjulumensis*
Ovum diameter 1.3-1.4 mm ..... *L. rothii*
10. In small clumps (of < 20 eggs) attached to vegetation ... 11
Not in small clumps (of < 20 eggs) attached to vegetation 13
11. Very small ovum (0.8-0.9 mm) brown and cream ..... *L. microbelos*
Small (1.0-1.2 mm) dark brown and cream 12
12. Ovum diameter 1.0 mm; capsule 2.5 mm (1.9-2.5 mm); three jelly envelopes ..... *L. bicolor*
Ovum diameter 1.2 mm; capsule diameter 1.7 mm; one jelly envelope ..... *Ranidella bilingua*
13. Surface film in shallow water (<5 cm) in inundated grassland. Black animal pole, white vegetal pole; discrete jelly envelope around ovum with loose sheet of jelly enclosing all eggs ..... *Notaden melanoscaphus*
Surface film in ephemeral or temporary pools. Animal pole not black. Discrete jelly capsules 14
14. Dark brown 15
Pale brown 17
15. Surface film of 200-350 eggs; capsule 2.2-2.9 mm ..... *Litoria caerulea*
Surface film or clump; < 100 eggs laid; capsule 3.2-3.7 mm 16
16. Ovum diameter 1.0-1.3 mm; three jelly envelopes *L. nasuta*
Ovum diameter 1.4 mm; two jelly envelopes .... *L. tornieri*
17. Ovum diameter 1.0-1.1 mm; capsule 1.9-2.3 mm *L. rubella*
Ovum diameter 1.2-1.3 mm; capsule 3.4-3.9 mm ..... *L.* sp. nr. *latopalmata*

(e) KEY TO LOWLAND TADPOLES

1. Black, large (up to 70 mm), 5/3 labial tooth rows ..... *Limnodynastes convexiusculus*
Not black 2
2. Tooth rows vary 2/3 to 6/3; eyes dorsal, narrowly separated; body dorso-ventrally flattened ..... *L. ornatus*
Tooth rows always 2/3; eyes dorso-lateral 3
3. Large (up to 70 mm). Bulbous bodies, usually dense and active in aggregations 4
Medium-sized (up to 50 mm). Not in dense and active aggregations 6
4. Lacking nasal groove. Dorsal pattern strong mottling, tail muscle with broad lateral stripe and along dorsal edge. Striped back pattern develops in stage 41. Papillary border widely separated superiorly ..... *Litoria dahlii*
Nasal groove in stages 32-41; tail muscle mottled; papillary border not widely separated superiorly 5
5. At stage 41 back pattern with well-defined dark patches ..... *Cyclorana longipes*
At stage 41 back lacking dark patches; longitudinal rows of small glands present ..... *C. australis*
6. Papillary border separated inferiorly 7
Papillary border not separated inferiorly 8
7. Papillae large in lateral area. Absent superiorly and just two inferiorly, flanking short third labial tooth row; horny beak strong; ventral surface white. Small (<25 mm) *Ranidella bilingua*
Papillae large, widely separated superiorly, separated inferiorly; horny beak weakly developed; ventral surface mottled red-purple and white. Small (<34 mm) *Uperoleia inundata*
8. Third lower row of labial teeth reduced to median structure of approx. 10 teeth 9
Third lower row of labial teeth not reduced 10
9. Papillae large, border not well-developed and widely separated superiorly. Horny beak very weakly developed. Tadpoles < 38 mm in length. Dark brown dorsum. Ventral surface dark brown becoming lighter. Very shallow water in inundated grassland ..... *Notaden melanoscaphus*
Papillae large, border well-developed and separated superiorly. Horny beak well-developed. Tadpoles up to 58 mm long; early stages pale yellow dorsum with dark brown dorsal and dorso-lateral stripes; during later development (after 27) the stripes fade and the dorsal and lateral surfaces become mottled brown with the pale yellow background. Dorsal surface of head becomes flattened. In temporary pools ..... *Litoria rothii*
10. Conspicuous band of white muscle on posterior of abdomen until stage 38. At 38 white patch develops just posterior of eye and develops into broad white stripe from eye to groin. Another white stripe anterior and below eye passing beneath eye and ends behind shoulder. Tadpole mottled brown early, uniform brown on dorsum later. ..... *L. bicolor*
No conspicuous band of white muscle on posterior of abdomen 11
11. Tail muscle pigmentation not in broad bands. <25 mm 12
Tail muscle pigmentation in broad bands, very small (< 20 mm); horny beak weakly developed. Papillary border widely separated. Dark dorsal pattern and dark head and lateral stripe ..... *L. microbelos*
12. Papillary border widely separated superiorly; horny beak rather weakly developed; tail fin lightly pigmented; tail muscle pigmentation in two stripes: one lateral halfway along tail, one along dorsal edge ..... *L. caerulea*
Papillae separated superiorly; horny beak well developed 13
13. Tail muscle has three stripes: one lateral, one on dorsal and on ventral edges. Tail fin edge becomes darker with development. Small tadpoles (< 35 mm). In stage 41 broad, white lateral stripe and narrow vertebral stripe appear. White patch anterior to and below eye ..... *L. rubella*

Tadpoles mottled brown. Tail muscle mottled brown. Up to 50 mm. Ground-dwelling hylids (*L. wotjulumensis, L. nasuta, L. tornieri, L.* sp. nr *latopalmata, L. inermis*).

Further specific identification is only possible from stage 41 onwards as follows:

At stage 41

(i) Toes strongly webbed ii
Toe webbing not well developed iii

(ii) Striped back pattern, long hindlimbs with longitudinal stripes ..... *L. nasuta*
Brown back pattern, broad conspicuous dark head stripe ..... *L. wotjulumensis*

(iii) Continuous dark brown stripe on posterior edge of tibia ..... *L. tornieri*
No continuous stripe *L. inermis* and *L.* sp. nr *latopalmata*
Specific identification of these species is only possible after stage 46.

At stage 46

Warty dorsal surface, indistinct head stripe, some flecking on the dorsal surface ..... *L. inermis*
Smooth dorsal skin, distinct head stripe
L. sp. nr *latopalmata*

(f) KEY TO LOWLAND FROGS

1. Inner metatarsal tubercle enlarged 2
   Inner metatarsal tubercle not enlarged 6
2. Medium to large size (greater than 35 mm). Outer metatarsal tubercle absent or not enlarged 3
   Small (to 35 mm). Enlarged outer metatarsal tubercle. Stout-bodied; short stocky limbs; conspicuous parotoid glands and glands at corner of mouth; grey with highly variable dark brown to red dorsal markings. Found in inundated grassland ..... *Uperoleia inundata*
3. Inner metatarsal tubercle not black 4
   Inner metatarsal tubercle black. Rounded snout. Stout body, short robust limbs. Pale brown with dark brown dorsal markings. When seized, exudes copious quantities of yellow sticky secretion from large number of dorsal glands. Found in inundated grassland ..... *Notaden melanoscaphus*
4. Belly smooth. Rounded snout. Medium-sized (up to 45 mm). Sandy with variable dark dorsal markings. Toes one-third webbed. Tympanum not visible. Conspicuous lateral fringes on toes. Males have nuptial pads on first two fingers. Calling occurs while free-floating in water
   Limnodynastes ornatus
   Belly granular. Slightly elongated snout. Large size (50-110 mm). Toes slightly webbed. Tympanum visible. Male nuptial pads on first finger only. Calling occurs on land 5
5. Medium-sized (to 55 mm). Well-defined dark patches on dorsal surface, usually with a vertebral stripe
   Cyclorana longipes
   Very large (to 110 mm). Pale brown with patches. A contrasting dark brown head stripe from snout to shoulder ..... *C. australis*
6. Toe discs conspicuous—expanded to twice width of digit 7
   Toe discs inconspicuous 10
7. Small (< 30 mm) and green; thin brown stripe along flanks; white stripe present from nose to groin .. *Litoria bicolor*
   Medium to large size (35-110 mm) 8
8. Brown or grey, 35-60 mm snout to vent length 9
   Very large green or olive frog (up to 110 mm). Common around dwellings ..... *L. caerulea*
9. Large (to 60 mm). Extensive toe webbing. Yellow and black markings in the groin and posterior of thigh. Elongate limbs ..... *L. rothii*
   Medium (to 45 mm). Webbing halfway up toes. Broad head stripe from nose to shoulder, sometimes continuing along flanks. Short, robust limbs ..... *L. rubella*
10. Small (< 25 mm) 11
    Medium to large (> 30 mm) 13
11. Slender body; granular belly 12
    Robust body; smooth belly; mottled brown; dark head stripe occasionally continuing along flanks; toe discs small and cylindrical; tympanum not visible; no webbing on toes; found in leaf litter in *Melaleuca* swamps
    Sphenophryne robusta
12. Up to 25 mm. Brown with variable dark markings on back. No toe discs. Unwebbed toes ..... *Ranidella bilingua*
    Up to 20 mm; brown with darker lateral stripes; dark eye stripe from nose to midway along flank; beneath this, white stripe from nose to shoulder. Toe discs present. Toes slightly webbed ..... *Litoria microbelos*
13. Toes at least partly webbed 14
    Toes unwebbed; large (to 65 mm); grey or olive with discrete dark patches on dorsal surface; conspicuous cream supralabial gland; stout body; tympanum not visible. Found in inundated grassland and floodplains
    Limnodynastes convexiusculus
14. Toes fully webbed; large (to 85 mm) 15
    Toes less than fully webbed; medium (to 50 mm) 16
15. Up to 85 mm; green with brown and olive back markings, cream patches on posterior of thigh. Belly smooth and white. Eyes prominent and dorsal. Found on flood plain; mostly aquatic ..... *Litoria dahlii*
    Up to 70 mm; brown, contrasting broad dark head stripe continuing along sides of body. Belly granular and cream. Eyes dorso-lateral ..... *L. wotjulumensis*
16. Striped dorsal pattern absent 17
    Conspicuous brown and white longitudinal stripes on back. Broad dark head stripe. Streamlined shape with elongated snout and extremely long legs. Black and yellow markings on posterior of thigh. Stripes and dark patches on legs. Toes half webbed ..... *L. nasuta*
17. Continuous dark brown stripe on anterior of tibia; red-brown dorsal surface in breeding season; pale brown to grey, dry season ..... *L. tornieri*
    No continuous tibial stripe; brown dorsal surface in breeding season 18
18. Usually indistinct head stripe; warty dorsum; some mottling; thigh markings not prominent. Males call from open areas usually on steeply sloping banks ..... *L. inermis*
    Distinct head stripe; smooth dorsum; occasional mottling; black and yellow markings on posterior of thigh; males call from open areas among grass tussocks adjacent to water ..... *L.* sp. nr *latopalmata*

ACCOUNT OF SPECIES

Family HYLIDAE

Cyclorana australis (Gray)

The largest frog in the area, *C. australis* is robust, 60-100 mm snout to vent length and a drab grey-brown. This species is fossorial, spending the day and dry season underground, usually at the base of trees or under logs. It is active at night from October to April, although the number of adults observed drops sharply after January, when metamorphosing juveniles predominate.

Breeding activity: Large numbers of males congregate early in the wet season. On warm nights during and following rain, they call from areas devoid of vegetation or at the base of grass tussocks near water. Breeding occurs at air temperatures of 24.5-28.5°C, 78.5-96.0% R.H. At deposition sites the water temperature is 31.0-33.5°C and the water depth 5-100 cm.

Eggs: Spawn is deposited at the edge of temporary pools. Initially it floats on the surface, but it sinks to the floor during early development. The clump fragments when disturbed. Eggs are laid in clumps of up to 7 000 although 100-1 000 are most common. The animal pole is dark brown and the vegetal pole white. Two jelly envelopes surround the ovum. Mean capsule diameter is 2.5 mm (2.3-2.8 mm) and mean ovum diameter 1.6mm (1.5-1.8 mm).

Developmental history: Hatching occurs at stage 17 in 1-2 days. The tadpoles become robust with a rotund body, elongate snout and deep fins (Fig. 5) and are pale brown or dull grey. The anus is dextral and the spiracle sinistral. The tooth row formula is 2/3 and there is a well-developed, elevated border of papillae surrounding the oral disc. There is a strong horny beak. The papillary border is separated superiorly by a broad median gap. A naso-orbital groove is present at stages 32-41. Stage 37 of Gosner (1960) is inapplicable because the metatarsal tubercle appears concurrently with differentiation of stages 37-38. Tadpoles attain a length of almost 70 mm at stage 41 (see Fig. 12) [mean 54.8 mm (40.9-68.2)].

Spawn of *C. australis* and *C. longipes* are often mixed, and the tadpoles form dense and very active aggregations. Tadpoles constantly rise to the surface, gulp air and then submerge, so producing the impression of boiling water. The tadpoles prefer the slightly cooler, deeper water, but low oxygen saturation levels induce them to rise to the surface.

Metamorphosing juveniles are found from December to April [mean S-V 21.3 mm (19.8-25.4 mm)], usually at the edge of pools where they feed on insects and on other frogs. Many juveniles are emerald green.

Notes: Tyler and Martin (1975) described and illustrated the tadpole and tadpole mouthparts of *C. australis* but had only poorly preserved series at stages 36-39. Tadpoles of *C. australis* cannot be distinguished from those of *C. longipes* until stage 41 when the mottled pattern on the dorsum of the latter species appears.

Cyclorana longipes Tyler and Martin

A robust, fossorial species attaining a maximum S-V length of 55 mm. Its habits are similar to those of *C. australis*, from which it is distinguished morphologically by its smaller size and densely mottled back pattern.

Breeding activity: Males congregate in large numbers from November to mid-December. Breeding occurs at air temperatures of 23.0-28.5°C, 85-96% R.H. At deposition sites water temperatures range 33.0-40.0°C and water depth is 5-100 cm.

Eggs: Spawn is deposited on the surface of the water at the edge of temporary pools in loosely-attached clumps of 50-2 000 eggs. Eggs sink to the floor in early development. The animal pole is brown and

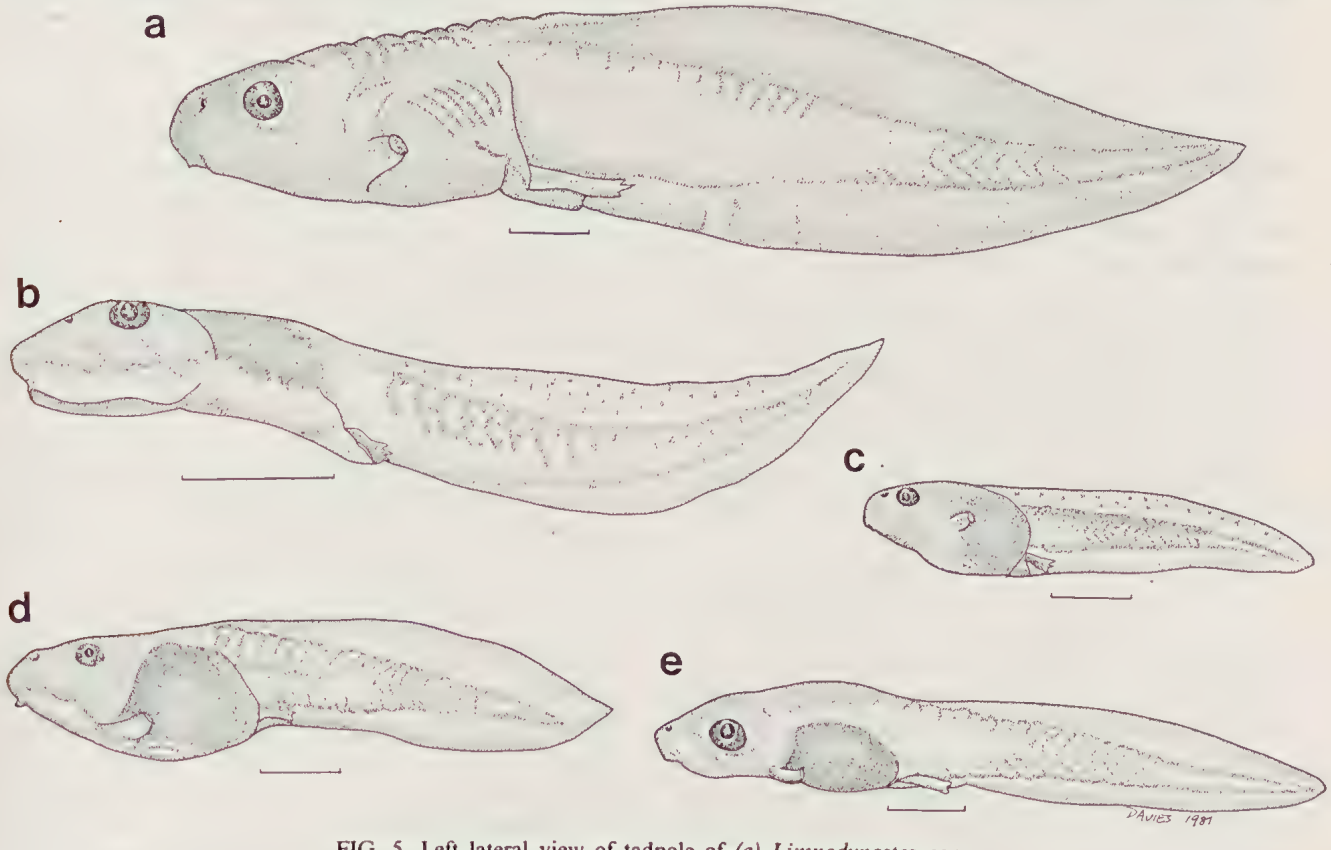

FIG. 5. Left lateral view of tadpole of *(a) Limnodynastes convexiusculus, (b) L. ornatus, (c) Notaden melanoscaphus, (d) Cyclorana longipes, (e) C. australis.* Scale bar = 5 mm.

vegetal pole white. Two jelly envelopes surround the ovum. Mean capsule diameter is 2.2 mm (1.9-2.5 mm) and mean ovum diameter 1.4 mm (1.2-1.5 mm).

Developmental history: Tadpoles are identical in form and habits to *C. australis* (Fig. 5) but attain a smaller maximum size at stage 42: mean 42.3 (32.8-59.5). Maximum growth occurs during stages 25-28 (Fig. 12), extending from a mean of 7.7 mm (6.8-8.3 mm) at stage 24 to 28.2 mm (24.6-30.5 mm) at stage 28. The tadpoles possess numerous long gill filaments at stages 22-24.

At 30°C juveniles metamorphosed after 40 days. At Jabiru juveniles were collected on 12 December 1978, in an area where pools were not formed until after 1 November 1978: a maximum of 42 days for complete development. At metamorphosis juveniles have a mean snout to vent length of 20 mm (19.1-21.1 mm).

Litoria bicolor (Gray)

A small, green tree frog bearing a white lateral stripe on the head and body. Commonly found on vegetation surrounding billabongs and streams. It is a nocturnal species and spends the day at the base of leaves of *Pandanus* and similar situations. Early in the wet season males call during the day.

Breeding activity: From November to April males call from the stems of grass, bushes and small trees inundated by or surrounding water. The nature of breeding sites appears to change during the wet season. Frogs are found near billabongs in the early wet season (October-December) but later in temporary pools by the roadside, and in swamps if there are sufficient calling sites for males. Huge choruses congregate early in the wet season, but much fewer males call at the temporary pools. Breeding occurs at air temperatures of approximately 26°C, 92-96% R.H.

Eggs: Spawn is deposited in temporary pools where there is emergent vegetation. Eggs are small [mean capsule diameter 2.5 (1.9-2.9 mm), mean ovum diameter 1.0 mm] with a black animal pole and a white vegetal pole. They are laid below the surface in clumps of 10-20 eggs, attached to submerged vegetation. Three jelly envelopes surround the ovum.

Developmental history: The eyes are widely spaced, the anus dextral and the spiracle sinistral (Fig. 6). The dorsum is mottled brown in the early stages; pigmentation increasing progressively until, at stage 41, the tadpole is uniform brown. At stage 38 a white patch appears just posterior to the eye and develops laterally until, at stage 41, it is a broad white stripe from the eye to the groin. By stage 41 another white stripe appears antero-ventrally to the eye, passing beneath it, and terminating just dorsal and posterior to the pectoral region. The ventral surface is white in these later stages. The tail muscle has stripes of pigment laterally and on the dorsal and ventral edges, the tail fins becoming increasingly pigmented with age, and the edges of the fins very dark. From stages 25-38 a conspicuous band of white muscle is present at the posterior end of the abdomen. The remainder of the abdomen is dark brown. The tooth row formula is 2/3. A well-developed, elevated border of small papillae, surrounds the oral disc, except for the superior margin (Fig. 7). There is a strong horny beak. Tadpoles attain a maximum length of 40.1 mm at stage 42 [mean 33.7 (27.4-40.1)] with maximum growth occuring between stages 25 and 27 [mean 11.2 (6.4-19.6) at stage 25 to mean 21.8 (20.3-22.7) at stage 27 (Fig. 8)]. At 30°C metamorphosis was completed in 77 days; no comparative data are available for field populations.

Litoria caerulea (White)

A large (up to 76 mm S-V), green, tree frog with well-developed parotoid glands and greatly expanded finger and toe discs. It spends the day hidden in crevices and hollows and is commonly found in dwellings.

Breeding activity: This species does not form large breeding choruses; males call individually or in small groups from exposed, elevated surfaces (e.g. walls, fences, branches of trees, roadside culverts). Calling occurs at night during or immediately after rain from October to March. Breeding occurs from November to February at air temperatures of 24-25°C, R.H. about 96%.

Eggs: Spawn is deposited in small ephemeral pools, in which emergent vegetation may be present or absent. Water temperature at deposition sites varies 28.0-38.0°C and water depths 5-50 cm. Spawn is laid as a surface film of brown eggs with white vegetal poles. The number of eggs in the clump is 200-2 000. Two jelly envelopes surround the ovum. Mean capsule diameter is 2.5 mm (2.2-2.9 mm), and mean ovum diameter 1.3 mm (1.1-1.4 mm).

Developmental history: Eggs hatch at stage 18, and attain a mean length of 8.1 mm (7.4-8.5 mm) by stage 24. A period of maximum growth follows, the embryo reaching 28.5 mm (25.6-31.2 mm) by stage 29. Maximum size is reached at stage 41 (Fig. 8): mean 41.0 mm (38.6-43.6 mm). Tadpoles are of the typical, lentic *Litoria* type. Eyes are widely spaced, anus dextral and spiracle sinistral. At stage 22 the tadpoles have extensive external gills. Tooth row formula is 2/3 and there is a well-developed, elevated border of large papillae surrounding the inferior edge of the oral disc (Fig. 7). The border does not extend superiorly to the first upper labial tooth row. Tadpoles are mottled brown with pigmentation increasing as development

proceeds. There are two brown, caudal stripes: a lateral one extending halfway along the tail and a second along the dorsal edge of the muscle for nearly the length of the tail (Fig. 6). Pigmentation of the tail fin increases progressively, but is sparse. Ventral surface dark, becoming progressively lighter with development. At 30°C one juvenile metamorphosed after 38 days and measured 18 mm S-V.

Litoria coplandi (Tyler)

A dark-brown frog of up to 40 mm snout to vent length. It is found commonly at night on sandstone boulders in and around streams in the escarpment. The species aggregate in crevices and in caves in the sandstone during the dry season.

Breeding activity: Males call from open, sandstone, rock surfaces near water, after rain from September to December. One of us (M.J.T.) has collected tadpoles of this species in July in the Kimberley, W.A., following unseasonal rain.

Eggs: Eggs have been found singly or in small clumps on the floor of shallow rock pools. We lack data on ovum and capsule size.

Developmental history: Early stages of development are unknown. At later stages the dark brown tadpoles can be readily identified because they have a brilliant white patch at the posterior end of the abdomen. This patch is a muscle layer; it becomes less conspicuous after stage 36 when the entire ventral surface becomes white. There is heavy pigmentation of the tail myotomes over the entire surface posteriorly, but only over the dorsal half anteriorly (Fig. 6). The tail fin is lightly pigmented. A naso-orbital groove appears at stage 37 but disappears by 41. Anus dextral; spiracle sinistral. The tooth row formula is 2/3 with a complete, well-developed, elevated border of small papillae surrounding the oral disc (Fig. 7). The horny beak is well-developed. Tadpoles attain a length of more than 45 mm. Juveniles metamorphose at a mean of 15.8 mm (13.6-18.8 mm). The duration of development is unknown, but metamorphosing specimens found on 21 February 1980 were collected in an area where sufficient amounts of rain had fallen only since the first days of January: a maximum of 52 days.

Litoria dahlii (Boulenger)

An aquatic species of the floodplain, *L. dahlii* is a large frog of up to 70 mm S-V. It is green with brown and olive back markings, or so heavily suffused with brown that the green is restricted to a mid-vertebral stripe. The dry season and early wet season are passed in cracks and crevices in the soil. When the plains are flooded, it emerges and can be seen in shallower, vegetated parts of the flooded areas, or basking at the perimeter of buffalo wallows.

Breeding activity: Little is known of its breeding habits. Males have been observed calling from a floating position in the water when rain was falling during periods of rising floods on the floodplains [I. Morris pers. comm.].

Eggs: The nature of the spawn is unknown. Ova dissected from gravid females are pigmented and have a mean diameter of 1.2 mm (range 1.1-1.3 mm).

Developmental history: The tadpoles have a bulbous but elongate body. The eyes are dorso-lateral, the anus median and the spiracle sinistral. The dorsal pattern comprises dense mottling on a dark background, until the longitudinal orientation of the stripe pattern of the adult is detectable at stage 41. Ventral surface dark, lightening to white by stage 42. Tail myotomes pigmented with a broad lateral stripe and another along the dorsal edge (Fig. 6). Slight pigmentation of the tail fin. The tooth row formula is 2/3. There is a well-developed, elevated border of small papillae around the oral disc, widely separated superiorly by a broad median gap (Fig. 7). The horny beak is well-developed. The tadpoles reach 35 mm by stage 26, and 52.6 mm (44.4-56.7) at stage 38. At stage 43 the metamorphosing juveniles measured 28.2 mm (23.2-32.5 mm).

Litoria inermis (Peters)

A pale grey to brown, medium sized (up to 40 mm S-V) ground-dwelling frog with slightly expanded terminal digital discs. One of three closely related 'ground hylid' species found in the area. Distinguished by its warty dorsum, poorly developed head stripe, relative limb length and reproductive strategy.

Breeding activity: Males call from open areas (usually steeply sloping banks) from November to March. The largest choruses occur early in the wet season. Breeding occurs at 23.5-28.0°C, 92-96% R.H. Deposition sites are temporary pools with little or no emergent vegetation, surrounded by gravel or sandy soils and vegetation cover within 1m of the water. Breeding occurs at a water temperature of 33-35°C in water of 5-60 cm depth.

Eggs: Spawn is laid in free-floating surface clumps of 96-330 eggs. Capsule diameter is large: 6.1 mm (5.8-6.8 mm). Ovum 1.3 mm (1.3-1.4 mm), brown with a white vegetal pole. There are three jelly envelopes.

Developmental history: Tadpoles are of the typical lentic *Litoria* form, with an elongate, oval-shaped body (Fig. 6). Anus dextral, spiracle sinistral. Tadpoles mottled brown on dorsum; abdomen dark, becoming lighter during development. Tail myotomes mottled; tail fin edges become very dark in late developmental stages. The tooth row formula is 2/3 and a well-developed, elevated border of small papillae surround

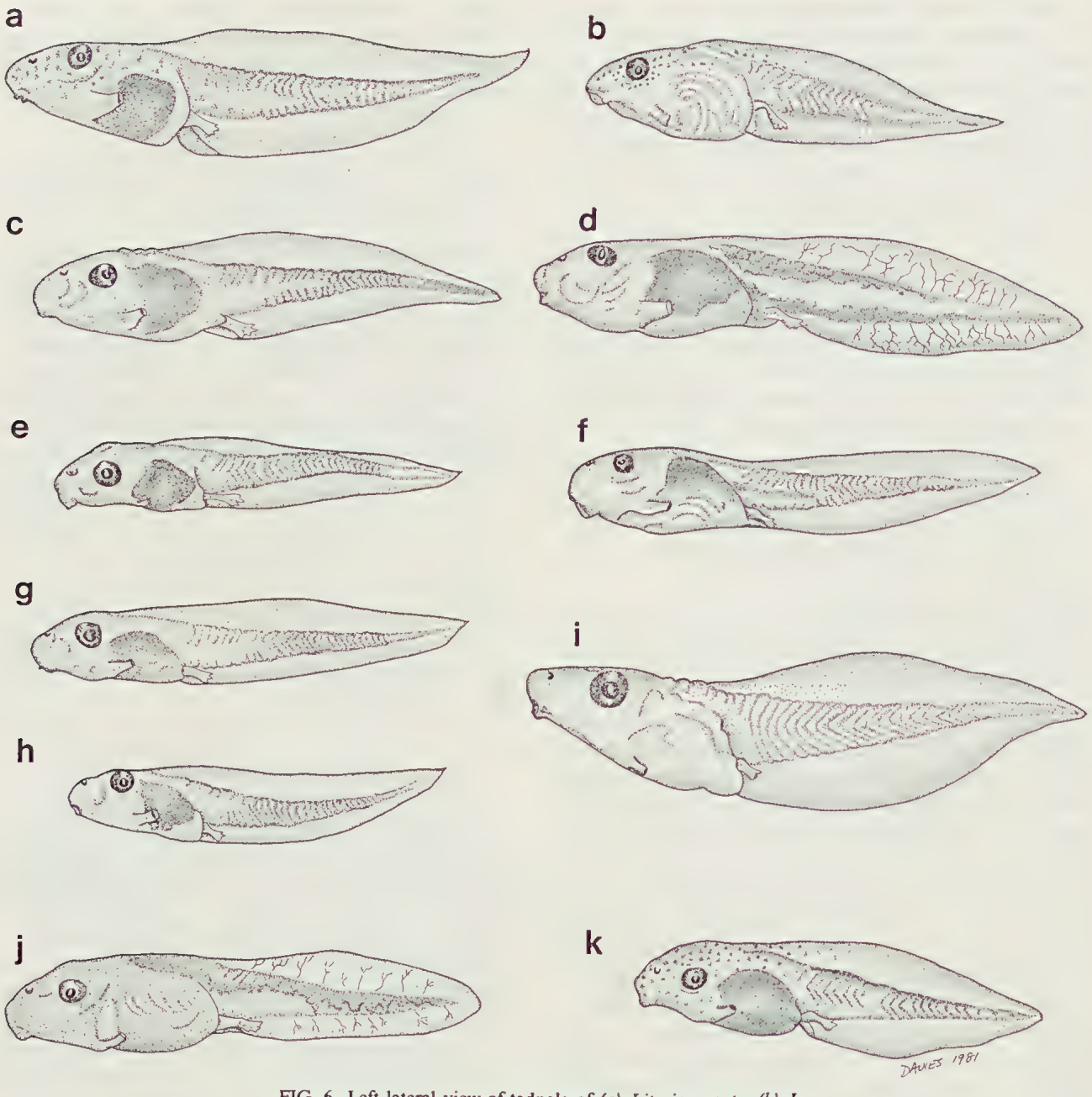

FIG. 6. Left lateral view of tadpole of *(a) Litoria nasuta, (b) L. bicolor, (c) L. tornieri, (d) L. dahlii, (e) L. inermis, (f) L. caerulea, (g) L.* sp. nr *latopalmata, (h) L. wotjulumensis, (i) L. rothii, (j) L. coplandi, (k) L. rubella.* Scale bar = 5 mm.

the oral disc. There is a well-developed horny beak; the papillary border is separated superiorly by a median gap. A small patch of brown pigment is present on the tip of the tail at stage 25, but this disappears by stage 26. Maximum growth is from stages 25-27, with the total length increasing from a mean of 6.3 mm (6.0-6.6 mm) at stage 24, to 21.2 (16.7-23.3 mm) at stage 27. There is then a gradual increase to the maximum mean length of 40.3 mm (38.3-43.5 mm) (see Fig. 8). At 30°C juveniles metamorphosed after 74 days.

Litoria sp. near **latopalmata**

A slender pale grey to brown species; often mottled with brown on the dorsum. Maximum length 37 mm S-V. Distinguished from other ground-dwelling hylids by its well-defined head stripe and smooth dorsum.

Breeding activity: Males call in large choruses from open areas within 1 m of water from October to April. Breeding has been observed from November to March, at 24-28°C, R.H. 89-96%. At deposition sites the water temperature was 33.6-41.2°C, and water depth up to 100 cm.

Eggs: Spawn is deposited in temporary pools; eggs are brown with a white vegetal pole and are laid as a surface layer, becoming clumped when even slightly disturbed. 50-350 eggs are laid with a mean capsule diameter of 3.6 mm(3.4-3.9 mm), and ovum diameter of 1.3 mm (1.2-1.3 mm). The ovum has three jelly envelopes.

Developmental history Tadpoles hatch at stage 18. They are mottled brown on the dorsum and have a dark abdomen which lightens to white by stage 41. The mottled pattern overlies the dark flanks. The tail myotomes are heavily pigmented and mottled, and the tail fin pigmented. The tadpole is of the typical *Litoria* form with a dextral anus and sinistral spiracle (Fig. 6). The tooth row formula is 2/3 and an elevated and well-developed papillary border surrounds the oral disc. The small papillae are separated superiorly. Maximum growth occurs at stages 25-27, the total length increasing from 6.2 mm (6.0-6.3 mm) at stage 24 to 24.4 mm (20.1-28.5 mm) at stage 27. Maximum length is reached at stage 38 with a mean total length of 44.8 mm (42.1-48.9 mm) (see Fig. 8). This length is maintained until absorption of the tail begins at stage 42. Two metamorphosing juveniles at stage 44 measured 14.8 and 16.1 mm respectively. At 30°C juveniles metamorphosed after 87 days. In the field juveniles were collected on 28 February 1980 in an area where suitable pools had been available only from January 5: a maximum of 54 days for development.

Litoria meiriana (Tyler)

A small brown or mottled slate-coloured frog reaching a maximum snout to vent length of 25 mm. It is diurnal and occurs in leaf-litter alongside streams in the sandstone escarpment. The dry season is spent in crevices and caves in the sandstone.

Breeding activity: Early in the wet season males call from leaf-litter and open rock faces at the edge of streams and pools in the escarpment. Breeding occurs from October to December. Amplectant pairs have been found at 26.5-27.0°C, R.H. 85.0-88.5%.

Eggs: Spawn is deposited beneath the water suface in a film of small clumps attached to rocks or to the floor of small, temporary pools in sandy escarpment streambeds. Eggs are small and light brown. One clutch contained 39 eggs.

Developmental history: Tadpoles are brown and have a dextral anus and sinistral spiracle. Tail myotomes are mottled brown and have a dark brown stripe along the dorsal edge (Fig. 9). The upper tail fin is pigmented. The ventral surface lightens during development until it is white at stage 42. Tadpoles have the typical *Litoria* tooth row formula and a well-developed, elevated border of small papillae surrounding the oral disc. The papillary border is narrowly separated superiorly (Fig. 9). There is a well-developed horny beak. Maximum growth occurs at stages 25-27 increasing from a mean of 4.05 (3.9-4.2 mm) at stage 22 to 6.2 mm (3.7-12.6 mm) at stage 25, and up to 21.3 mm (15.9-25.1 mm) at stage 27. The growth is then very slight, increasing to only a mean of 25.4 mm (25.3-25.6 mm) at stage 41 (Fig. 10). At 30°C tadpoles reached stage 42 in 45 days. At Ngarradj warde djobkeng (Birndu) juveniles were found in large numbers on 30 November 1978. The first appreciable rains in the area and observations of calling and spawning were in the first days of November [G. Miles pers. comm.]: a maximum of 30 days for development.

Litoria microbelos (Cogger)

A small, slender, brown species attaining a maximum S-V length of 16 mm. It occurs among long grass at the edges of pools and streams. The day is spent under logs, stones and vegetation near streambeds or flooded grassland.

Breeding activity: Males call from the base of grass tussocks or on grass stems during or immediately following rain, from October to February. Early in the wet season this species and *L. bicolor* form large breeding choruses in pools at the edge of billabongs. Where *L. bicolor* is present, *L. microbelos* males call from the base of the grass tussocks; however, if *L. bicolor* is absent, *L. microbelos* calls from the grass stems normally occupied by *L. bicolor.*

Eggs: Eggs are deposited in small clumps among grass stems. Mean ovum diameter is 0.8 mm (0.8-0.9 mm); the animal pole is brown and the vegetal cream. No complete jelly capsules were found.

Developmental history: (Derived from specimens taken at Mitchell Plateau, W.A.) Embryos hatch at stage 20 at a total length of 3.0 mm (2.8-3.1 mm). At stage 24 total length is 4.1 mm (4.0-4.2 mm) increasing to 11.4 mm (10.8-12.0 mm) at stage 27. No data are available for later stages. There is dark pigmentation on the dorsal surface, and a dark head and lateral stripe. There are bands of pigment on the tail muscle. The tail is lightly pigmented. The tooth row formula is 2/3. A border of relatively large papillae surround the oral disc. This is widely separated superiorly. The horny beak is rather weakly developed.

Litoria nasuta Tschudi

An exceptionally long-legged, elongate-bodied species attaining a maximum S-V length of 50 mm. It is brown with dark brown and white longitudinally orientated back markings, and a conspicuous dark head stripe. It is abundant, except upon the escarpment.

Breeding activity: Males call from open areas between grass tussocks within 1 m of water from November to March. Breeding occurs from November to February. Amplectant pairs have been found at 25.0-26.5°C, R.H. 96%. At spawn deposition sites water temperatures were 30.5-41.2°C, and water depths of 15-30 cm.

Eggs: Spawn is deposited in small, temporary pools on inundated grassland, usually where there is sparse emergent vegetation. Eggs are dark brown with cream vegetal hemispheres. Spawn is laid as a surface film which becomes a clump when disturbed. There are 50-100 eggs/clump, with a mean capsule diameter of 3.4 mm (3.2-3.7 mm) and ovum diameter of 1.1 mm (1.0-1.3 mm). There are three jelly envelopes.

Developmental history: The tadpole is of typical lentic *Litoria* form. The anus is dextral and spiracle sinistral. The tooth row formula is 2/3 with a well-developed, elevated papillary border surrounding the oral disc and separated superiorly (Fig. 7). Tadpoles are mottled brown with the ventral surface whitening during development. The tail myotomes are mottled, and the tail fin pigmented (Fig. 6). The characteristic, striped, back pattern of the adults becomes evident at stage 42. The extreme leg length, striped leg pattern and reduced toe-webbing distinguish this species at stage 41 from closely-related species. Eggs hatch at stage 18 at a mean length of 1.9 mm (1.8-1.9 mm). They attain 6.0 mm (5.2-6.3 mm) by stage 24, whereupon there is maximum growth until stage 28, 33.3 mm (29.0-38.3 mm) (Fig. 12). The maximum mean length of 48.8 mm (44.8-55.7 mm) is reached at stage 39. Tadpoles remain at this size until absorption of the tail commences at stage 43. At 30°C juveniles metamorphose after 31 days at a mean length of 18.7 mm (17.3-21.6 mm).

Litoria personata Tyler, Davies & Martin

A small, rock-dwelling species, attaining a maximum S-V length of 35 mm. It is brown or grey with a conspicuous dark head stripe. The dry season is spent in cracks and crevices in the escarpment.

Breeding activity: Males call from open rock faces and elevated positions at the edge of streams in the escarpment from November to late January. Tadpoles and transforming juveniles were collected in late April 1978 by M. J. Tyler.

Eggs: The eggs are unknown.

Developmental history: Tadpoles have been found in temporary pools upon the escarpment and in stream beds at its base. The tadpoles are highly distinctive, being dark brown dorsally with gold to yellow dorsolateral stripes. The ventral surface is creamy white. There is a dark grey band between the eyes, and an arrowhead-shaped dark grey patch anteriorly. The body shape is typical of other *Litoria* from lotic habitats. The body is flattened, the tail muscle is well developed and the fins narrow. The tooth row formula is 2/3, with a complete, elevated papillary border surrounding the oral disc. The horny beak is weakly developed. Anus dextral, and the spiracle sinistral. Tadpoles measured 41.8-55.1 mm at stages 41-45 (Tyler et at., 1979). They form aggregations and are often seen maintaining a static, horizontal position 5-10 cm beneath the surface.

Litoria rothii (de Vis)

A large tree frog attaining 60 mm snout to vent length. It is brown and has bright yellow and black markings in the groin and upon the posterior surface of the thigh. It is commonly seen on buildings in the area.

Breeding activity: Males call between November and March following rain from elevated positions near water. Breeding occurs from November to March at 27.5-28.5°C, R.H. approximately 96%.

Eggs: Spawn is deposited in small clumps in temporary pools in which emergent vegetation may be present or absent. Eggs are dark brown with a cream vegetal pole and have a mean diameter of 1.4 mm (1.3-1.4 mm). The capsule is 4.6-5.4 mm. It is fragile and easily ruptured. There are three jelly envelopes.

Developmental history: Tadpoles are pale yellow on the dorsal surface and white ventrally when they hatch at stage 18. There are dark brown stripes, one branches forward anterior to the eyes and another on each side of the body from the nostril to the end of the tail. A bright yellow spot is visible on the dorsal surface just anterior to the eyes. At stage 23 external gill filaments are present. Anus dextral, spiracle sinistral. The body is of the typical *Litoria* lentic water form, but the tail fins are much deeper than in other species in the area (Fig. 6). The stripes fade during development and the dorsal and lateral surfaces become mottled brown. The dorsal surface of the head becomes very flat. The tooth row formula is 2/3. The third lower row of labial teeth is absent or reduced to a small, median structure bearing less than ten teeth. A border of well-developed large papillae is elevated and sourrounds the oral disc except superiorly (Fig. 7). There is a well-developed horny beak. The tadpoles undergo a maximum growth period in stage 25 increasing in total length from 7.0 mm (6.8-7.4 mm) at stage 24 to 19.9 mm (7.2-38.2 mm) at stage 25 increasing to 31.4 mm (25.3-43.0 mm) in stage 26. A maximum of 58.2 mm was measured in a stage 40 tadpole (Fig. 8). At 30°C a juvenile metamorphosed after 146 days; in the field, however, a large juvenile was collected on 11 March 1980 in an area where water was not present until after 5 January 1980: a maximum of 65 days for development.

Litoria rubella (Gray)

A small brown tree frog of up to 40 mm S-V; it is abundant throughout the area except in the escarpment. The day is spent in hollows, under logs and rocks in dry streambeds and on banks, in dwellings and cisterns.

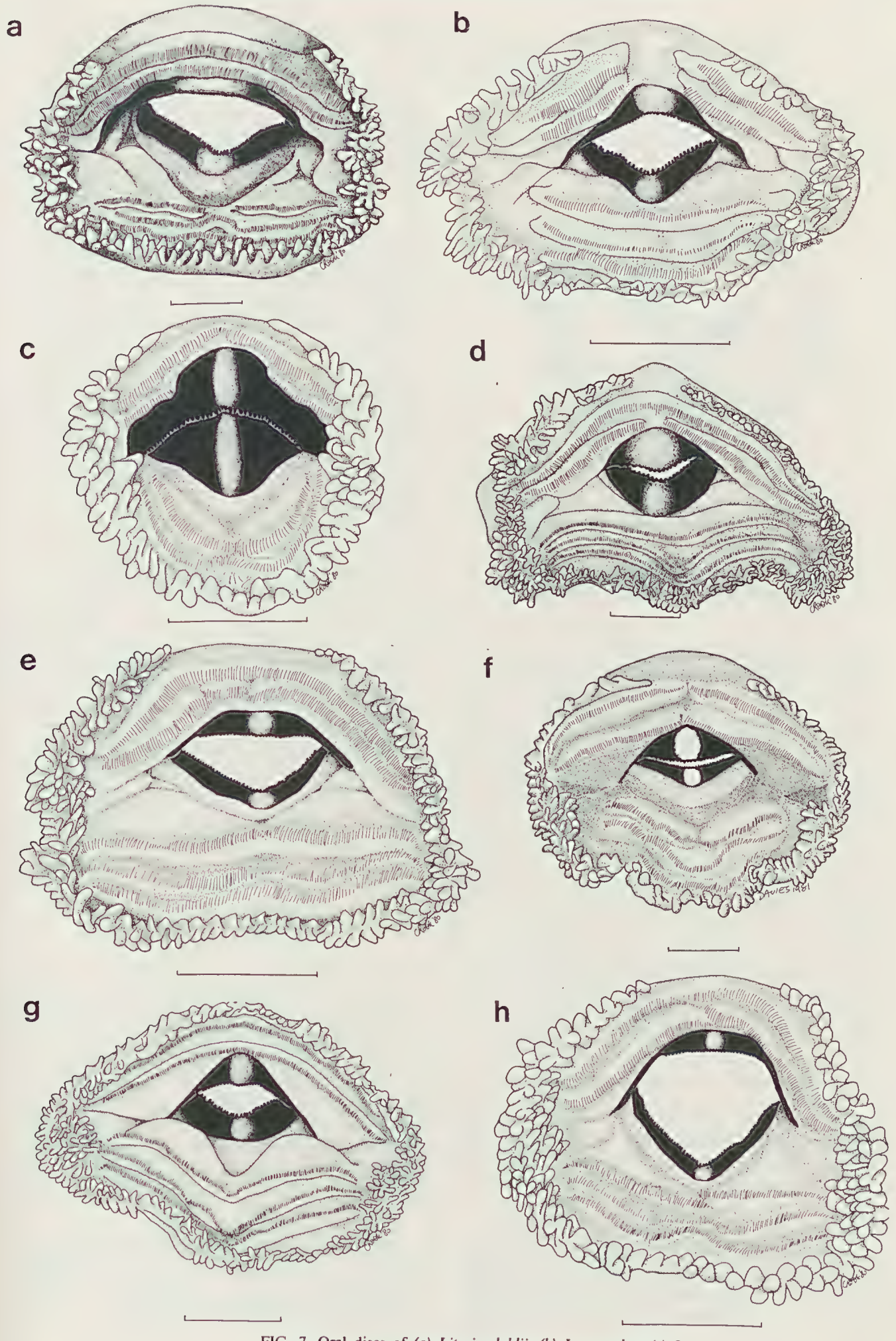

FIG. 7. Oral discs of *(a) Litoria dahlii, (b) L. caerulea, (c) L. rothii, (d) L. wotjulumensis, (e) L. bicolor, (f) L. nasuta, (g) L. coplandi, (h) L. rubella.* Scale bar = 1 mm.

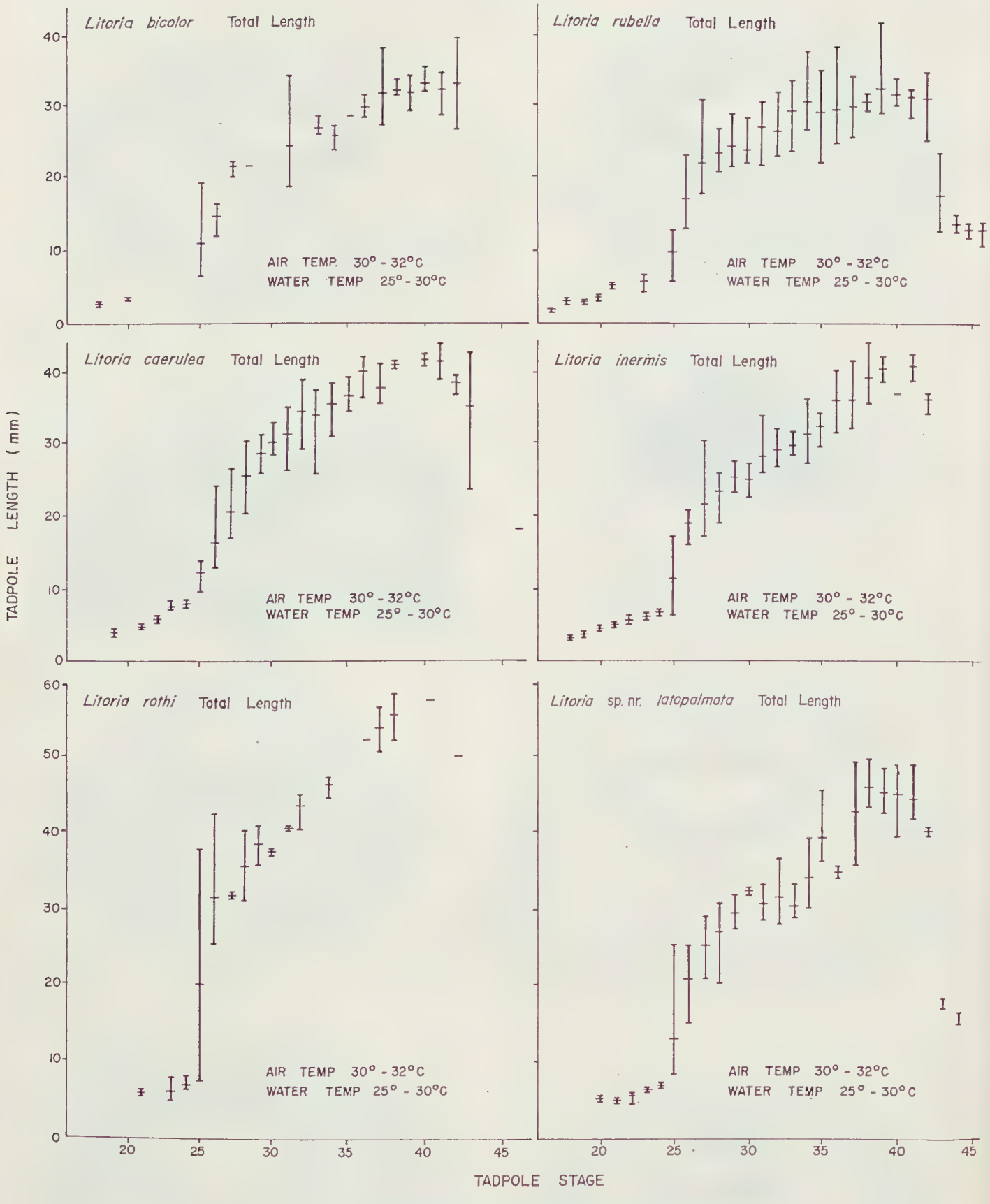
Litoria bicolor Total Length
AIR TEMP. 30° - 32°C
WATER TEMP 25° - 30°C
Litoria rubella Total Length
AIR TEMP 30° - 32°C
WATER TEMP 25° - 30°C
Litoria caerulea Total Length
AIR TEMP 30° - 32°C
WATER TEMP 25° - 30°C
Litoria inermis Total Length
AIR TEMP 30° - 32°C
WATER TEMP 25° - 30°C
Litoria rothi Total Length
AIR TEMP 30° - 32°C
WATER TEMP 25° - 30°C
Litoria sp. nr. *latopalmata* Total Length
AIR TEMP 30° - 32°C
WATER TEMP 25° - 30°C
TADPOLE LENGTH (mm)
TADPOLE STAGE

FIG. 8. Growth gradients in tadpoles of various species of *Litoria*.

Breeding activity: Males call from a variety of areas near water ranging from open grassy areas to elevated sandy hillocks, usually on the ground. Silent males and amplectant pairs are often found within 0.3 m of a calling male. Calling and breeding occur from November to April, although both activities appear concentrated early and late in this period. Amplexus occurs at 25.0-26.5°C, R.H. 92-96%.

Eggs: Spawn is deposited in the form of small, floating surface films in temporary pools with or without emergent vegetation. Water temperatures of up to 40°C have been recorded at the deposition site, water depth is 30-100 cm. Eggs have a brown animal pole and cream vegetal pole. There are 40-300 eggs in a clump. The capsule diameter is 2.1 mm (1.9-2.3 mm), and ovum diameter 1.0 mm (1.0-1.1 mm). There are three jelly envelopes.

Developmental history: At 30°C the eggs hatch within three days at stage 21. Tadpoles attain maximum growth during stages 25-27, increasing in total length from 5.9 mm (4.5-6.9 mm) at stage 23 to 22.2 mm (17.9-30.9 mm) at stage 27. Maximum length is reached at stage 42 (Fig. 8), 31.2 mm (25.3-34.8 mm). Tadpoles have a 2/3 tooth formula, and small papillae in a well-developed, elevated border surround the oral disc except superiorly (Fig. 7). The horny beak is well developed. The spiracle is left ventro-lateral and the anus right median. The body is rotund, mottled brown on the dorsum, and white on the ventral surface (Fig. 6). The mottling becomes darker during development. There is dark pigmentation on the tail muscle in three stripes: a lateral one flanked by others along the dorsal and ventral extremities. This pigmentation also occurs on the outer edge of the tail fin becoming increasingly darker during development. A shallow nasal groove from eye to nose is present in later stages. At stage 41, a broad, white, lateral stripe and a vertebral stripe appears and is retained until after metamorphosis. There is also a white patch anteriorly to and below the eye. The remainder of the dorsum is uniform brown. At 30°C the juveniles metamorphose after 38 days. A collection of tadpoles with metamorphosing juveniles present was made on 10 February 1980 from a pool that could not have been filled before 5 January 1980: a maximum of 37 days for complete development.

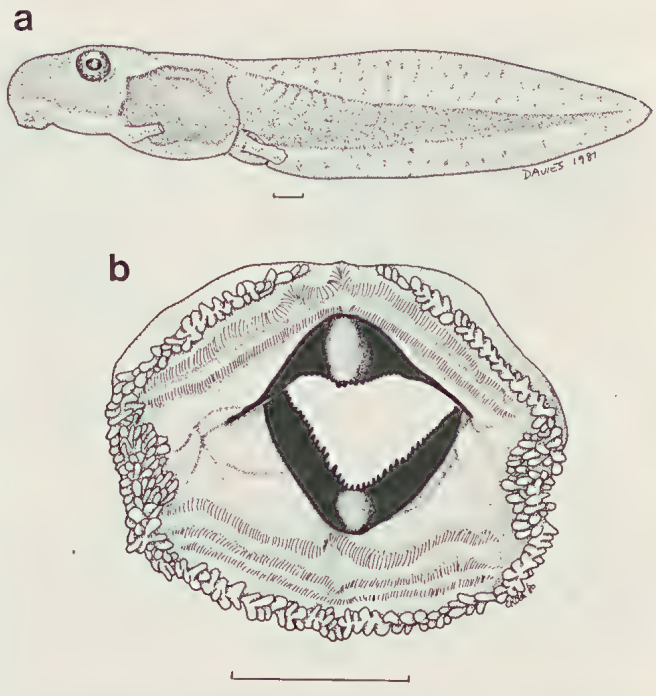

FIG. 9. *(a)* Left lateral view of tadpole, and *(b)* oral disc of *Litoria meiriana*. Scale bar = 1 mm.

Litoria tornieri (Nieden)

A moderate-sized, ground-dwelling hylid (40 mm) distinguished by a narrow continuous brown stripe on the anterior margin of the tibia. In the breeding season the species is reddish with a conspicuous, dark brown head stripe.

Breeding activity: Males call from cover, either under leaves or at the base of grass tussocks within 3 m of water. Calling occurs from October to April; breeding has been observed from November until March. Breeding occurs at 25.0-26.5°C, R.H. 92-96%.

Eggs: Eggs are laid in temporary pools in inundated grassland where the water depth is less than 100 cm. The dark brown eggs have a white vegetal pole and are laid as a surface layer which becomes a clump when disturbed. Capsule diameter is 3.4 mm (3.2-3.7 mm) and ovum diameter 1.4 mm. There are two jelly envelopes.

Developmental history: Tadpoles are mottled brown on the dorsum and have a dark abdomen which lightens to white during development. The tail myotomes are mottled, and the tail fin pigmented. The tadpole is of typical lentic *Litoria* form (Fig. 6). The anus opens right of median and the spiracle left lateral. The tooth row formula is 2/3, and a well-developed, elevated border of small papillae incompletely surrounds the oral disc. The horny beak is strongly developed. Tadpoles hatch at stage 18 and reach a mean total length of 6.5 mm (6.1-7.1 mm) at stage 24 (Fig. 12). A period of accelerated growth occurs, increasing the total length to 26.4 mm (23.2-29.9 mm) at stage 27. Growth increases slowly until it reaches a maximum of 38.8 mm (34.6-44.0 mm) at stage 38. One juvenile was 15.1 mm at metamorphosis. At 30°C tadpoles reached stage 40 in 44 days.

Litoria wotjulumensis (Copland)

A large ground-dwelling hylid (reaching 70 mm S-V), with an elongate body, extensive webbing of the toes and a broad dark conspicuous head stripe. Its call has a repertoire of rattles and chuckles.

Breeding activity: Males call from open areas at the edge of water and face the water. Calling occurs from October to March, and the species breeds in the early months of the wet season. Breeding has been observed at 25-27°C, R.H. 75-92%.

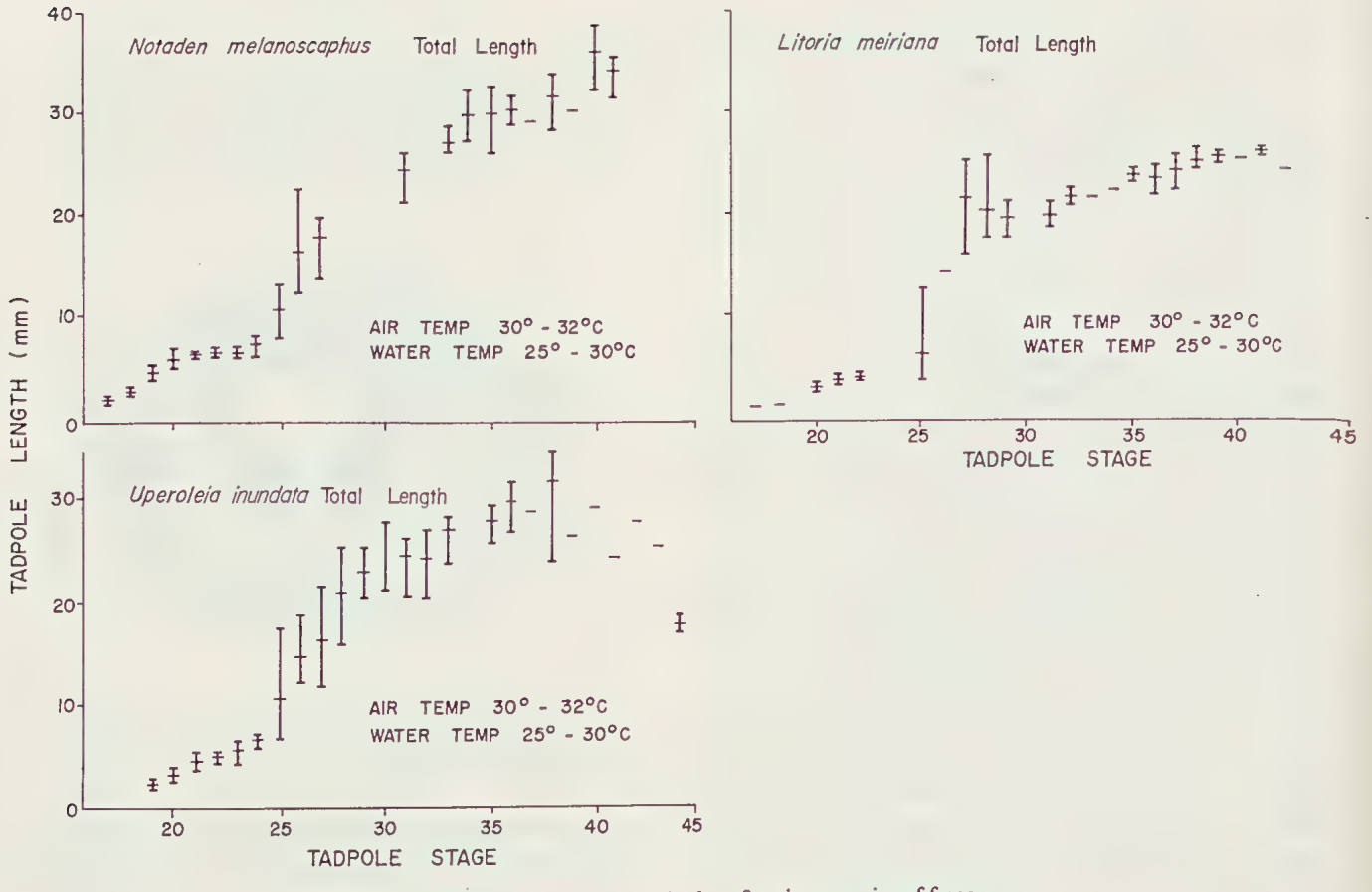
Notaden melanoscaphus Total Length
AIR TEMP 30° - 32°C
WATER TEMP 25° - 30°C
Litoria meiriana Total Length
AIR TEMP 30° - 32°C
WATER TEMP 25° - 30°C
Uperoleia inundata Total Length
AIR TEMP 30° - 32°C
WATER TEMP 25° - 30°C
TADPOLE LENGTH (mm)
TADPOLE STAGE
TADPOLE STAGE

FIG. 10. Growth gradients in tadpoles of various species of frogs.

Eggs: Spawn is laid in temporary pools in sandy or gravelly soil. Eggs were found at water temperatures of 32-33°C in water 10-50 mm deep. The dark brown eggs have a cream vegetal pole and deposited as a floating clump of 30-200 eggs, occasionally attached to surface vegetation. Mean capsule diameter 4.6 mm (4.2-4.9 mm), ovum diameter 1.75 (1.6-1.9 mm). There are three jelly envelopes.

Developmental history: Tadpoles have well-developed external gills at stages 20-24. The body is typical of lentic *Litoria* (Fig. 6). The tadpole is mottled dark brown and the ventral surface is white. Anus dextral, spiracle sinistral. The tail myotomes are heavily mottled, and the upper tail fin pigmented. The tooth row formula is 2/3 and a well-developed, elevated border of small papillae incompletely surrounds the oral disc (Fig. 7). The horny beak is strongly developed. At stage 25 the total length is 12.6 mm (8.2-21.2 mm) increasing to 40.5 mm (39.3-42.3 mm) at stage 41 (Fig. 12). Juveniles metamorphosed at a mean length of 17.0 mm (15.5-18.0 mm). At 30°C tadpoles reached stage 42 after 53 days.

Limnodynastes convexiusculus (Macleay)

A large, broad-bodied frog with a mottled tubercular dorsum, common in swampy areas and abundant on the floodplains. It is found among long grass usually in small hollows or burrows. It is cryptic in its habits.

Breeding activity: Males call from October until April from small hollows among long grass near water.

Eggs: There is little known of the eggs except that they are laid in the form of a foam nest.

Developmental history: The tadpoles are a distinctive, intense black with long, deep tail fins (Fig. 5). Anus median, spiracle lateral and sinistral. The tooth row formula is 5/3 and there is an elevated border of large papillae which is widely separated superiorly around the oral disc. The horny beak is rather weakly developed. The body is robust and the dorsal surface slightly flattened. Tadpoles do not occur in large numbers. They attain a maximum length of 70 mm.

Limnodynastes ornatus (Gray)

A rotund, fossorial frog up to 45 mm S-V with a highly variable back pattern. This species has no preferred habitat (although it is uncommon in the larger billabongs) and is abundant in the area.

Breeding activity: Males call whilst free-floating in water. Calling occurs from October to March, and breeding from November to February. Breeding has been observed at air temperatures of approximately 26°C, R.H. 88.5-96.0%. Any pool deeper than 2 cm is used for breeding purposes, including ditches newly dug for sewer pipes and shallow, water-filled depressions on the road surface. At deposition sites water temperatures were 27-38°C.

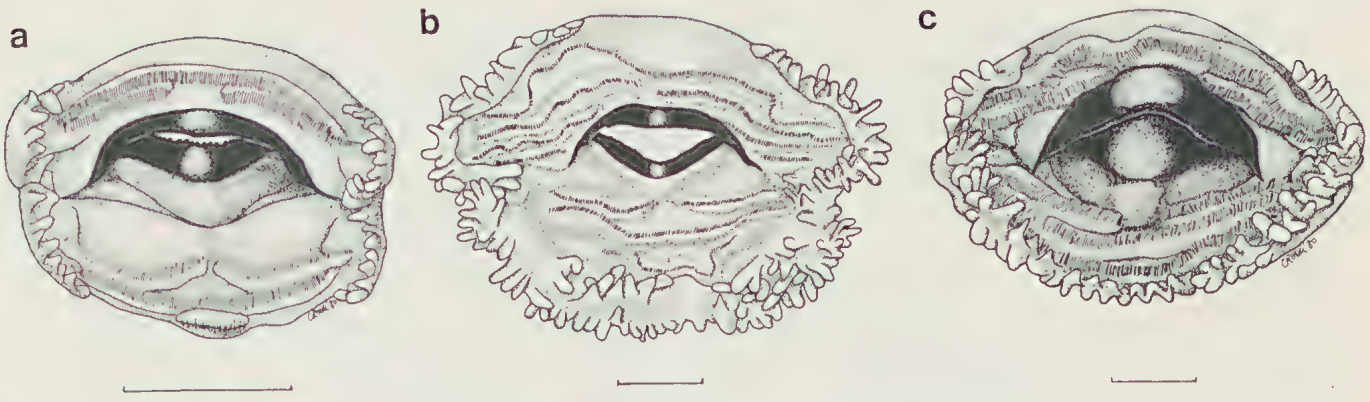

FIG. 11. Oral discs of *(a) Notaden melanoscaphus, (b) Limnodynastes ornatus, (c) Cyclorana longipes.* Scale bar = 1 mm.

Eggs: Eggs are deposited in a foam nest floating on the surface of the water. The foam rapidly collapses to form a thin surface film. The number of eggs per clump is 155-1 630 with a mean of 645. Ovum black with a white vegetal pole and diameter of 1.2 mm (1.0-1.3 mm). The eggs have one jelly envelope; capsule diameter 1.6 mm (1.45-1.8 mm).

Developmental history: The embryos hatch after 18 hours at stage 20 at a length of 4.4 mm (4.0-4.7 mm). Long filamentous gills are present from stages 22-24. Growth is steady throughout development. The tadpoles are brown on the dorsal surface with a darker patch between the eyes, and on the tail myotomes. Eyes dorsal and close together giving the tadpole a distinctive appearance. Anus median, spiracle sinistral. Body flattened dorso-ventrally (Fig. 5). Tooth rows vary from 2/3 to 5/3. A well-developed, elevated border of large papillae, separated superiorly, surrounds the oral disc (Fig. 11). The horny beak is weakly developed. The tadpoles form dense and active aggregations, and cannibalism is prevalent, particularly in ephemeral pools. A maximum length of 31.0 mm (29.5-32.8 mm) is reached at stage 39 (Fig. 12) and juveniles metamorphosed at 10.3 mm (6.5-11.6 mm). At 30°C metamorphosis was completed after 26 days. In the field, spawn laid on 28 November 1977 developed to stage 46 on 23 December 1977: 25 days.

Megistolotis lignarius Tyler, Martin and Davies

A moderate-sized (60 mm S-V) robust species with short, very muscular limbs and a very large tympanum. Inhabits scree slopes and escarpments and hides beneath rocks and boulders, and in caves during the dry season.

Breeding activity: Males call from beneath boulders in or near streambeds in the escarpment. Breeding commences in late November.

Eggs: The creamy yellow eggs are deposited in a foam nest under rocks in static water.

Developmental history: Hatching occurs at stage 21. The body and fins are intense black. Anus median, spiracle sinistral. The tadpoles have highly efficient suctorial mouthparts. The tooth row formula varies from 4/3 to 6/3. A border of small papillae is well developed, elevated and narrowly separated superiorly. The horny beak is strongly developed. Cannibalism has been noted in the laboratory. Tadpoles reach a length of over 50 mm by stage 42. A juvenile metamorphosed after 65 days and measured 23.3 mm (Tyler, Martin & Davies, 1979).

Notaden melanoscaphus Hosmer

A medium-sized, extremely robust, fossorial frog with short limbs. It is pale brown with large dark blotches on its back, and when seized exudes a copious amount of sticky, yellow secretion from large dorsal glands. It is found in grasslands throughout the area and passes the day buried in sandy soil.

Breeding activity: Males call during or immediately after rain from shallow, water-filled depressions. Calling occurs from December to March, and breeding from early January to March. Air temperatures range 23.0-26.5°C, R.H. 96-100%.

Eggs: The spawn is deposited as a surface film in shallow, ephemeral pools in inundated grassland. Water temperatures range 27-36°C and the depth 1-30 cm. Eggs have a black animal pole and white vegetal pole. The number of eggs is 500-1 000 with a mean of 833. The eggs have individual capsules joined by a sticky loose layer of jelly. The mean capsule diameter is 2.7 mm (2.6-2.9 mm) and ovum diameter 1.4 mm (1.3-1.45 mm). There is one jelly envelope.

Developmental history: The spawn sinks as the eggs develop. The larvae hatch at stage 20 at 5.8 mm (5.0-6.8 mm). External gills are present at stages 22-24. Anus dextral, spiracle sinistral and lateral (visible from a dorsal view). Dorsal pigmentation dark brown, with the adult back pattern becoming apparent in stage 41. Ventral surface dark brown becoming lighter as development proceeds. Tail myotomes dark brown

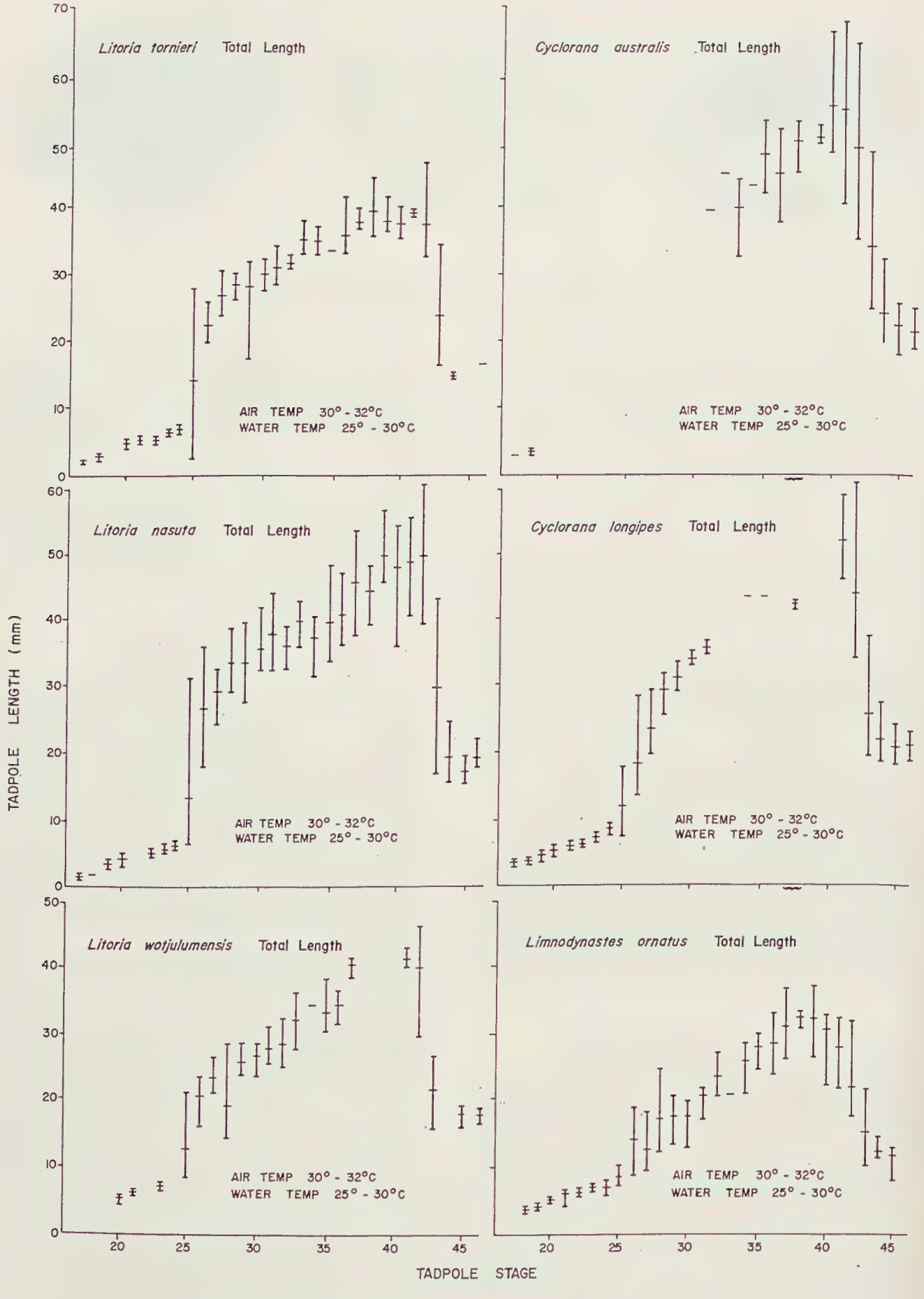
Litoria tornieri Total Length
AIR TEMP 30° - 32°C
WATER TEMP 25° - 30°C
Cyclorana australis Total Length
AIR TEMP 30° - 32°C
WATER TEMP 25° - 30°C
Litoria nasuta Total Length
AIR TEMP 30° - 32°C
WATER TEMP 25° - 30°C
Cyclorana longipes Total Length
AIR TEMP 30° - 32°C
WATER TEMP 25° - 30°C
Litoria wotjulumensis Total Length
AIR TEMP 30° - 32°C
WATER TEMP 25° - 30°C
Limnodynastes ornatus Total Length
AIR TEMP 30° - 32°C
WATER TEMP 25° - 30°C
TADPOLE LENGTH (mm)
TADPOLE STAGE

FIG. 12. Growth gradients in tadpoles of various species of frogs.

and tail fins pigmented. Upper tail fin much deeper than lower (Fig. 5). Tooth row formula is 2/3 with one complete upper and two complete lower rows. The third lower tooth row is reduced to a median structure of 10 teeth (Fig. 11). A border of large papillae is not well developed and is widely separated superiorly. The horny beak is very weakly developed. The tadpoles increase in total length from 7.25 mm (6.1-8.1 mm) at stage 24, to 17.2 mm (13.7-19.2 mm). At stage 24 a tadpole measured 25.4 mm (Fig. 10). The tadpoles inhabit very shallow water (1-5 cm) deep in inundated grassland. Water temperatures exceeding 41°C have been recorded there. There is heavy flocculent material on the floor, and the tadpoles spend most of the time lying in this layer. In the field a juvenile was found on 26 February 1979 in an area where adult *Notaden* were not present before 4 January 1979: a maximum of 53 days for complete development.

Ranidella bilingua Martin, Tyler and Davies

A small, brown species with variable darker and lighter markings on its back, and measuring a maximum of 25 mm. It inhabits inundated grasslands in the wet season; the dry season is spent on the soil under logs and rocks.

Breeding activity: An opportunistic breeder; males call and mating occurs whenever sufficient rain falls, even in dry season showers. Males call from the base of grass tussocks in or around water.

Eggs: Eggs are laid in small clumps attached to vegetation. The animal pole is dark brown and the vegetal pole creamy white. There is a single jelly envelope. The capsule diameter is 1.74 (± 0.16 mm) and ovum diamter 1.17 (± 0.04 mm) (Martin, Tyler & Davies, 1980).

Developmental history: Derived from Martin *et al.* (1980). Eggs hatch at stage 20 and have a total length 4.0-4.5 mm. There are no external gills present. At stage 25 the total length is about 6.5 mm, increasing to 24.5 mm by stages 40-41. The tadpoles are dark brown with the myotomes and ventral surface white. Upper and lower fins are pigmented. The tooth row formula is 2/3 with the third lower row very short. Few large papillae border the lateral area of the mouth, but are completely absent superiorly. Posteriorly there are just two papillae flanking the third short tooth row. The horny beak is strongly developed. Juveniles collected at Mitchell Plateau, W.A. metamorphosed at 7.5-8.4 mm S-V after 13-14 days.

Uperoleia arenicola Tyler, Davies and Martin

A small, squat species only found in a sandy streambed in the escarpment of Birndu (Ngarradj warde djobkeng) near Ja-Ja. Its colour is variable (pale grey to dark slate) and there are bronze parotoid glands. The specimens were found on steep-sided sandy banks of the stream.

Breeding activity: Data are confined to observations on calling males. We noted that they called without moving from their burrows and were still covered with fine sand.

Uperoleia inundata Tyler, Davies and Martin

A moderate-sized species of up to 30 mm S-V length. It is grey with highly variable dark brown to red dorsal markings. In the wet season it inhabits inundated grasslands.

Breeding activity: From January to April the males call from shallow water at the base of grass tussocks, under leaves and logs, and from grass stems in water. Large breeding choruses are formed. Breeding occurs during January and February, at 24.5-29.0°C, R.H. 89-100%.

Eggs: Spawn is deposited in shallow (2-5 cm), inundated grasslands, water temperatures 27.2-28.6°C. Eggs are laid in small clumps (<5) or individually, and immediately sink to the bottom. They have a sticky, tough outer capsule which accumulates a covering of particles. The ovum has a dark brown animal pole with a light brown vegetal pole. There is one jelly envelope, and the capsule has a diameter of 1.8 mm (1.5-2.0 mm). The ovum diameter is 1.25 mm (1.1-1.4 mm).

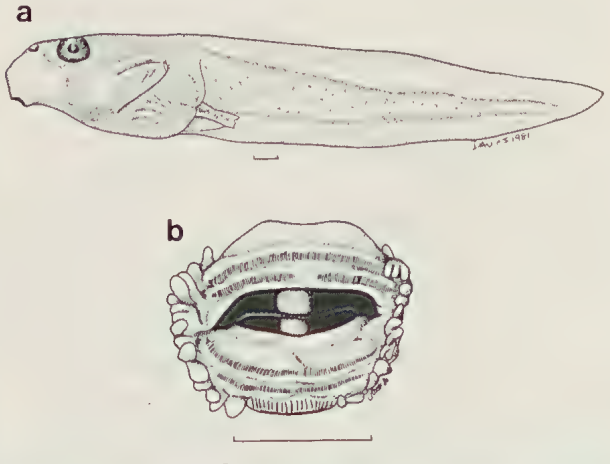

FIG. 13. *(a)* Left lateral view of tadpole, and *(b)* oral disc of *Uperoleia inundata*. Scale bar = 1 mm.

Developmental history: Embryos hatch at stage 20 at a total length of 2.7 mm (2.5-2.8 mm). External gills are absent. At stage 25 the total length is 10.4 mm (6.6-17.1 mm). Tadpoles are dark brown on the dorsal and lateral surfaces, and mottled with red-purple and white on the ventral surfaces. Anus dextral, spiracle sinistral and visible from above. The tail myotomes are mottled with brown and the upper tail fin is pigmented (Fig. 13). The tooth row formula is 2/3 with the upper row divided. A poorly-developed

border of large papillae, widely separated superiorly and inferiorly, surrounds the oral disc (Fig. 13). The horny beak is weakly developed. Tadpoles grow to a length of 31.0 mm (23.25-33.9 mm). At stage 44 the tadpoles had a size range of 16.0-17.7 mm (Fig. 10). Juveniles were collected on 2 March 1979 in an area where there was not water prior to 10 January 1979: a maximum of 51 days for metamorphosis.

Sphenophryne robusta (Fry)

A very small, brown cryptic, terrestrial species found in 'paperbark swamps', rainforest remnants and in the escarpment. It inhabits leaf litter.

Breeding activity: Little is known of its biology. Other sphenophrynine microhylids lay eggs out of water and exhibit direct development within the egg capsules. It may be assumed that this species behaves similarly.

BEHAVIOUR

Activity Patterns

Adults of most species are active only at night but there are a few exceptions. We have observed spasmodic diurnal calling activity by *Litoria rothii* and *L. rubella*, whilst in the wet season *Cyclorana australis* and *L. dahlii* commonly bask in the sun at the edge of pools. On the morning of 29 November 1977 M.D. and M.J.T. captured two basking *C. australis* at Ja Ja. The air temperature there was 33°C. Dorsal skin temperatures were 33.0°C and 34.4°C respectively, cloacal temperatures 33.4°C and 34.2°C and ground beneath the frogs 32.0°C and 34.0°C. Our experience with *C. australis* at the study site and elsewhere in the Northern Territory indicate that the basking frogs are not alert; they press their bodies close to the ground and if approached quietly they can be captured by hand. We are uncertain of the upper limit of temperature at which basking is discontinued. Beyond the study area at a site adjacent to the Stuart Highway 99 km south of Elliot on 17.12.80, two of us (Davies, Tyler) with A. A. Martin collected specimens beside a temporary pool where the air temperature was 37.0°C; soil beneath one frog was 36.2°C and the adjacent water temperature 30.0°C. The body temperature was 36.4°C. During experiments at Adelaide designed to induce burrowing, *C australis* remained on the surface for two hours when exposed to a heat lamp elevating the surface temperature of the adjacent soil to 40°C (J. Sanders, pers. comm.).

Litoria dahlii is less readily approached whilst basking than is *C. australis*, and we have not captured basking specimens.

Litoria meiriana is habitually diurnal. This small species shelters in the shade at the perimeter of rock pools and is unique amongst Australian anurans in having the ability to travel across the surface of static water in a series of rapid bounces to avoid enemies or to capture small, flying insects.

Seasonality of Reproductive Behaviour

From May to September any rainfall in the Magela Creek system is a rare event (see Jabiru rainfall records plotted by Tyler and Crook 1980). The area is hot and dry and activity by frogs is minimal.

The nature of dry season refuges influences the onset of reproductive activity only slightly. The lowland species in general require the formation of shallow bodies of water, and it is evident that the fossorial species are amongst the first to breed there (Fig. 14).

We have observed the effect of rainfall upon the escarpment and upon the floodplain and, despite the absence of comparative rainfall records, it is evident that even slight falls upon the escarpment are sufficient to induce breeding. This is because the impermeable surfaces result in rainfall flowing across the rock and accumulating in every depression, so providing numerous breeding sites. These breeding sites may be produced by localised showers in the wet season, and our observations in the Northern Territory and the Kimberley Division of Western Australia indicate that some species breed during these unseasonal light or localised rains. Irrespective of how localised these rains may be, they are of greatest significance upon the escarpment, benefitting species such as *Litoria personata, L. coplandi* and *Megistolotis lignarius.*

Fecundity

Clutch size is commonly at variance with the total egg complement because some individuals deposit several clutches on a single night. This habit probably explains the wide disparity in clutch sizes recorded in Table 2. Other species such as *Litoria coplandi* and *Ranidella bilingua* scatter single eggs and the complement cannot be calculated from field observations.

Salthe and Duellman (1973) demonstrate that within any reproductive mode there is a positive correlation between egg complement and adult size. Thus large species tend to lay more eggs than small ones. This is borne out by our data (Table 2) and there is very slight interspecific variation in egg diameters. Thus the maximum ovidiameter of *C. australis* is 1.8 mm and in *L. microbelos* 0.9 mm (100% variation). This is despite the fact that there is a 500% difference in body length (100 mm S-V in *C. australis* against 20 mm in *L. microbelos.*

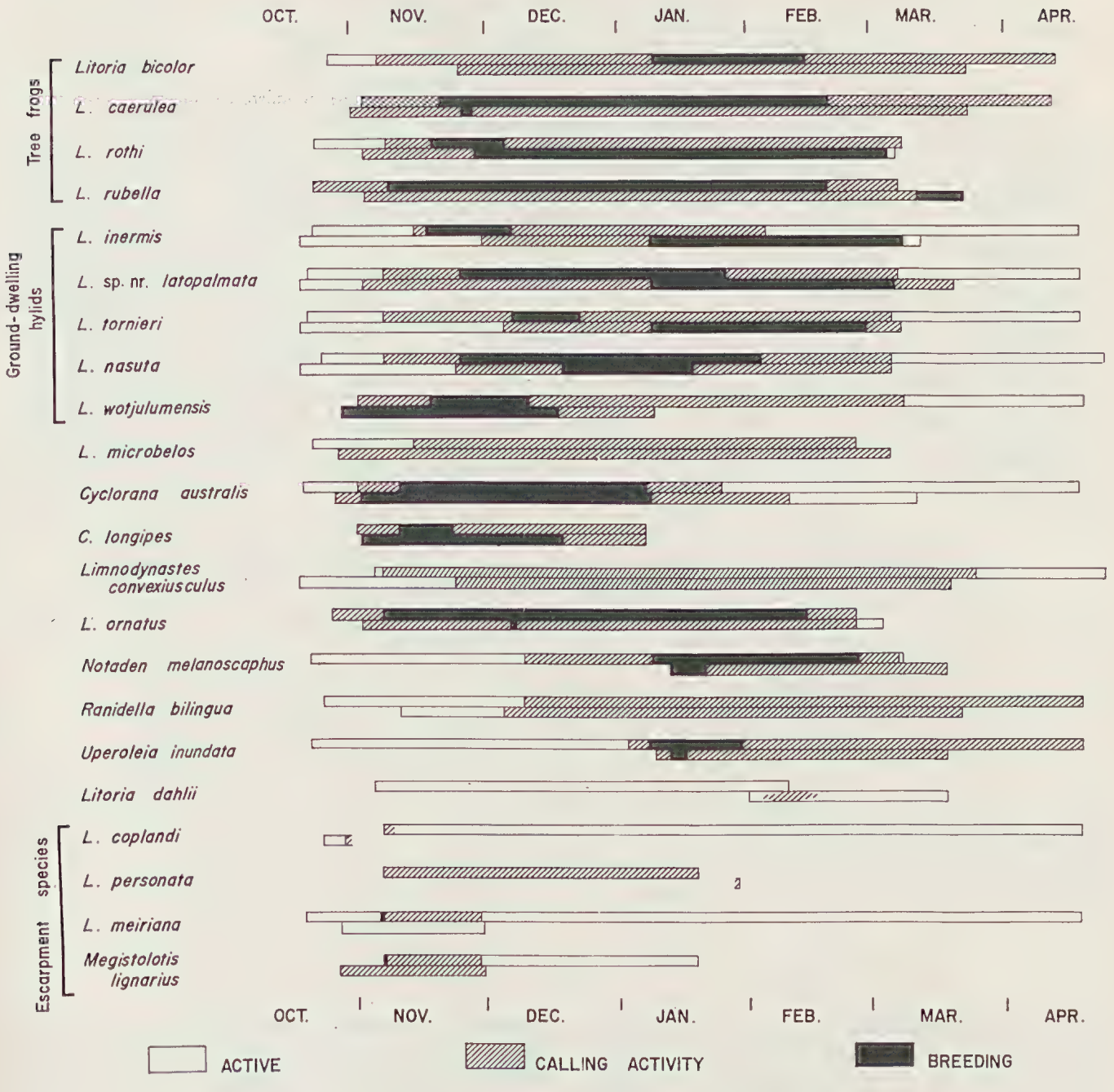

FIG. 14. Wet season activity of frogs in the Magela Creek System. For each species, the upper trace represents data derived from 1978-79 season, and the lower trace 1979-80 season.

Capsule diameter is the sum of the ovidiameter surrounded by the expanded (hydrated) oviducal secretions deposited upon the ova. In the species examined the outer capsule diameter was approximately 1.5-2.5 times the ovidiameter (Table 2). Figures for *L. inermis, L. rothii* and *L. wotjulumensis* are exceptional, the maximum capsule diameter of *L. inermis* being 6.8 mm and maximum ovidiameter 1.4 mm (Table 2).

Reproductive Modes

In the 24 species there are only three distinct reproductive modes, one of which is represented by only one species (Table 3), and in fact 20 species share the generalised anuran pattern of laying eggs in water and having aquatic larvae. In general the Australian hylids are remarkably conservative in reproductive modes, and presumably the high proportion of hylids in the study fauna contributed to the limited overall diversity. Elsewhere in sub-tropical faunas, diverse reproductive regimes have been recorded (Salthe & Duellman, 1973; Crump, 1974). Certainly in temperate southern Australia, diversity of reproductive modes is associated with leptodactylid rather than hylid species (Tyler, Watson & Martin, 1981, Table 2). Nevertheless the seasonal aridity and limited forestation of the Magela Creek system environment probably are inimical to many reproductive modes. For example, there is very limited leaf litter or other low layers of

TABLE 2: CHARACTERISTICS OF SPAWN

	Clutch number	Clutch size	No. of jelly envelopes	Capsule diam. (mm) median	Capsule diam. (mm) range	Ovidiameter (mm) median	Ovidiameter (mm) range
Cyclorana australis	1	7 000	2	2.5	(2.3-2.8)	1.65	(1.5-1.8)
Cyclorana longipes	2	1 000-1 615	2	2.2	(1.9-2.5)	1.35	(1.2-1.5)
Litoria bicolor	2	50-195	3	2.4	(1.9-2.9)	1.00	
Litoria caerulea	4	103-328	2	2.5	(2.2-2.9)	1.25	(1.1-1.4)
Litoria inermis	7	96-330	3	6.3	(5.8-6.8)	1.35	(1.3-1.4)
Litoria sp. nr. *latopalmata*	10	52-921	3	3.6	(3.4-3.9)	1.25	(1.2-1.3)
Litoria meiriana	3	39-115	-	-	-	-	-
Litoria microbelos	1	40	-	-	-	0.85	(0.8-0.9)
Litoria nasuta	2	50-100	3	3.4	(3.2-3.7)	1.15	(1.0-1.3)
Litoria rothii	1	504	3	5.0	(4.6-5.4)	1.35	(1.3-1.4)
Litoria rubella	1	715	3	2.1	(1.9-2.3)	1.05	(1.0-1.1)
Litoria tornieri	2	69-190	2	3.4	(3.2-3.7)	1.4	
Litoria wotjulumensis	4	31-50	3	4.5	(4.2-4.9)	1.75	(1.6-1.9)
Limnodynastes ornatus	19	155-1 632	1	1.6	(1.45-1.8)	1.15	(1.0-1.3)
Megistolotis lignarius[1]	1	352	-	-	-	1.85	(1.8-1.9)
Notaden melanoscaphus	4	561-1 028	1	2.7	(2.6-2.9)	1.4	(1.3-1.55)
Ranidella bilingua	-	-	1	3.1	(2.5-3.7)	1.12	(1.05-1.2)
Uperoleia inundata	1	400	1	1.8	(1.5-2.0)	1.25	(1.1-1.4)

[1] From Tyler et al. (1979)

TABLE 3: REPRODUCTIVE MODES AMONGST THE SPECIES AND GENERA OF THE FROG FAUNA OF THE MAGELA CREEK SYSTEM

	Cyclorana	*Litoria*	*Limnodynastes*	*Megistolotis*	*Notaden*	*Ranidella*	*Uperoleia*	*Sphenophryne*	Total
(a) Eggs in water, aquatic larvae	2	14	-	-	1	1	2	-	20
(b) Eggs in foam nest on water, aquatic larvae	-	-	2	1	-	-	-	-	3
(c) Eggs on land, larvae on land	-	-	-	-	-	-	-	1	1

high humidity necessary to create the conditions under which direct development, or the delayed emergence from egg capsules is physically possible. Evidently similar factors operate in South America where the greatest diversity of reproductive modes is associated with environmental conditions rather than systematic factors: the majority of modes occurring in species occupying forest habitats (Crump, 1974; Lynch, 1979).

Developmental Spans

Water temperature and aggregation density both affect the developmental span of tadpoles, although there is substantial variation in developmental rates within the progeny hatching from a single clump. Our observations in the laboratory and field suggest that this variation is a normal phenomenon, but that in the wild the 'slow' developers die. In Table 4 we have recorded the means and ranges of the shortest span in each species. (The shortest span is the period taken for the first individual of a clump to complete metamorphosis.) Recording the shortest span is realistic because of the ephemeral nature of many of the pools. Thus abbreviation of the developmental period ensures survival, whereas those individuals with the longest developmental span are most prone to perish as the pool evaporates.

We reared in the laboratory 24 clumps of *L. nasuta* spawn, and observed a distinct tendency for the spawn laid late in the season to complete development in a shorter span than that laid early in the season (Fig. 15).

At Jabiru water temperatures tend to be highest at the early part of the wet season; we recorded tadpoles in water at 42.7°C in early January. This is 3.5°C higher than the maximum for any species of frog known to Main (1968) but, as he suspected, is quite typical of summer diel temperatures experienced by eggs and tadpoles at localities in northern Australia. (The maximum noted by Tyler, Davies and Martin (unpublished) is 45.0°C in a rock pool occupied by spawn of *L. meiriana* at Mitchell River Falls, W.A. in February, 1979.)

TABLE 4: DEVELOPMENTAL SPANS IN DAYS UNDER FIELD AND LABORATORY CONDITIONS

	Field (ca. 30-40°C)		Laboratory (30°C)		
	n	$\bar{x}$	n	$\bar{x}$	±S.D.
Cyclorana australis	1	29	1	37	—
Cyclorana longipes	2	35 (33-37)	7	48 (31-66)	12
Litoria bicolor	—	—	2	53 (25-82)	40
Litoria caerulea	—	—	10	66 (28-94)	29
Litoria coplandi	1	52	1	—	—
Litoria inermis	—	—	10	87 (62-117)	20
Litoria sp. nr *latopalmata*	1	54	7	96 (61-122)	23
Litoria meiriana	1	30	1	45	—
Litoria nasuta	—	—	23	71 (31-120)	22
Litoria rothii	1	65	2	144 (142-146)	3
Litoria rubella	1	37	5	45 (28-84)	22
Litoria tornieri	—	—	11	97 (62-129)	24
Litoria wotjulumensis	—	—	5	71 (39-120)	37
Limnodynastes ornatus	1	25	5	38 (21-63)	17
Megistolotis lignarius	—	—	—	65[1]	—
Ranidella bilingua	1	14[2]	—	—	—
Uperoleia inundata	—	—	1	99	—

[1]From Tyler et al. (1979)
[2]From Martin et al. (1980)

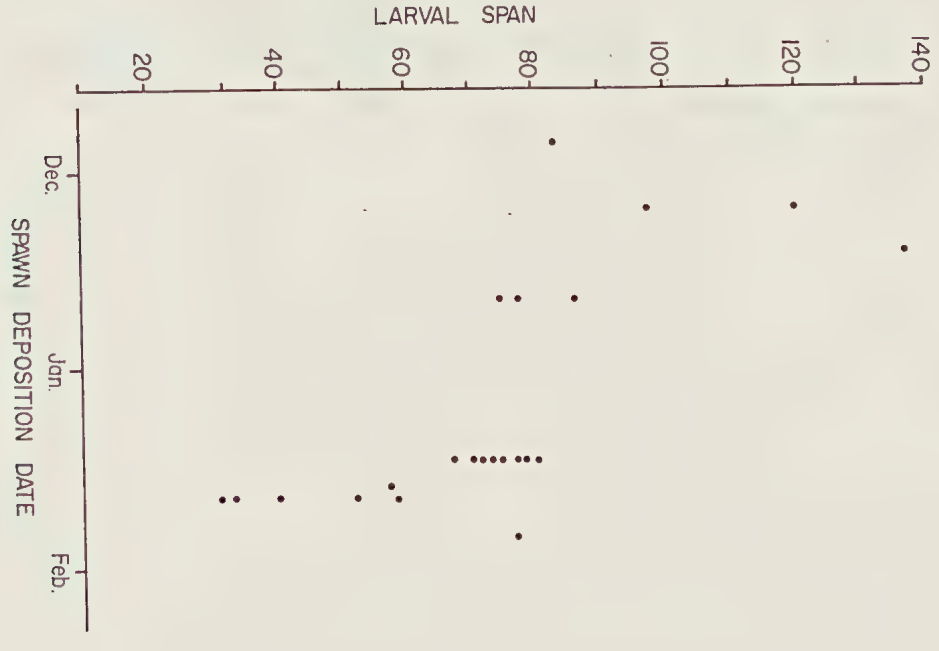

FIG. 15. Larval life span of *Litoria nasuta* at differing egg deposition times.

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THE TAXONOMY OF THE *ATRAX ADELAIDENSIS* SPECIES-GROUP (MACROTHELINAE: MYGALOMORPHAE) WITH NOTES ON BURROWING BEHAVIOUR

by

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ABSTRACT

GRAY, M. R., 1982. The taxonomy of the *Atrax adelaidensis* species-group (Macrothelinae: Mygalomorphae) with notes on burrowing behaviour. *Rec. S. Aust. Mus.* **18** (19): 441-452.

The funnel web spiders, genus *Atrax*, making up the *adelaidensis* species-group from South Australia are described: *Atrax adelaidensis* sp. n., *A. eyrei* sp. n. and *A. flindersi* sp. n. Their distribution in relation to that of the genus is outlined. The absence of a serrula in all species and the distinctive modification of the first leg in males of *A. adelaidensis* are recorded. The unique burrow structure comprising shaft plus side-chamber with trapdoor is described and the presence of a surface door in early juvenile burrows is noted.

INTRODUCTION

Funnel web spiders (genus *Atrax* O. P. Cambridge, 1877) have a distribution that is essentially gondwanian. They are commonly represented in coastal and highland habitats from southern Queensland to Tasmania. North of the Gladstone area in southern Queensland records are available for three specimens only (all females), from Queensland, Papua New Guinea and the Solomon Islands respectively. These records have not been confirmed or added to since the original collections of 60 to 80 years ago and one of them definitely represents a locality data error: *Anaepsiada* (syn. *Atrax*) *ventricosa* Rainbow and Pulleine 1918 recorded from Cloncurry, northwest Queensland in fact was collected from Tamborine Mountain, southeast Queensland and is probably a juvenile *A. validus* Rainbow and Pulleine. In the drier conditions to the west of the Great Dividing Range their numbers fall off rapidly. To the west of the Grampian Range area in Victoria there appears to be a gap in the distribution of the genus until it reappears again in the highlands of the Mt. Lofty-southern Flinders Ranges and the southern Eyre Peninsula of South Australia (Fig. 32). These westernmost, isolated representatives of the genus *Atrax* form the *adelaidensis*-group.

NOTATION FOR SPINES

Leg surface abbreviations for spine counts: pd = prodorsal; rd = retrodorsal; pv = proventral; rv = retroventral. The leg spination data given in the holotype and paratype descriptions refers to the range of variation encountered (total spine counts per surface) both in these specimens and the remaining type series; left and right side leg spine counts are included.

Atrax adelaidensis group

Diagnosis: Characteristic burrow with side chamber closed by trapdoor. Cephalic area moderately raised, serrula absent. Males lack apophysis on leg 2, sometimes with tibia and metatarsus of leg 1 swollen.

Comments: The presence of the *adelaidensis*-group was first reported by Main (1964) who then referred them to the genus *Hadronyche* L. Koch, 1872. Main (1967, 1976) also noted the burrow structure, including the presence of a side chamber closed by a trapdoor. Gray and Sutherland (1978) indicated that at least three species could be recognised and referred them to the genus *Atrax*, noting that their burrow structure set them apart from all other members of the genus. Their placement within *Atrax* is clearly indicated by the presence of three tooth rows in the fang groove, spinose tarsi and many cuspules on both the labium and maxillae.

The *adelaidensis* group shows two morphological features of particular interest. These are the absence of a serrula and the modification of the first legs in males of *A. adelaidensis*. In a survey of mygalomorph genera Platnick (1977) recorded the presence of a serrula in an unidentified species of funnel web spider. Examination of many eastern funnel web species by the present author indicates that serrula development in *Atrax* is highly variable—in some species the serrula is large and obvious, in others reduced or absent (Plates 5-7). The modification of the first leg in males of *A. adelaidensis* (Fig. 2) is most unusual for this genus. In other funnel web species it is the second leg that may show significant modification in the form of tibial and metatarsal apophyses. Not only the position but also the type of modification differs in *A. adelaidensis*, where the entire first metatarsus and tibia are swollen. A slight swelling of the second metatarsus is also evident.

This modification of the first leg may be of significance in the context of the generic relationships of

Atrax. The systematic position of the genus as a member of the family Dipluridae has long been problematical. Diplurid genera possessing male second leg modifications such as *Evagrus* Ausserer and *Allothele* Tucker are not closely related to *Atrax*. Simon (1892) used the presence of numerous cuspules on the labium and maxillae as key characters in his recognition of the genera *Atrax, Porrothele* Simon and *Macrothele* Ausserer in his Macrotheleae and Raven (1980) considers that these genera comprise a natural grouping within his Hexathelidae. Zoogeographically, as well as morphologically and behaviourally, the New Zealand genus *Porrothele* is a logical candidate for relationship with *Atrax*. Thickening of leg segments in these genera may be independent derivations but could be additional indicators of relationship.

The distribution limits of the *Adelaidensis* species are not clear as yet. However, the general areas of species distribution can be approximately defined as follows: *A. adelaidensis*—Mt. Lofty Range and adjacent coastal plain; *A. eyrei*—southern Eyre Peninsula; *A. flindersi*—southern Flinders Range (Fig. 32). These areas correspond with open forest habitats of the type best developed in the Mt. Lofty Range. In drier areas such as the Flinders Range the spiders tend to be concentrated in riparian habitats where open forest (though with a reduced understory) persists.

KEY TO FEMALES

1. Prodorsal surface of patella III with 18 to 26 spines. Pigmented lower lateral surface of abdomen marked with several paler bars ..... *Atrax adelaidensis*
—Prodorsal surface of patella III with 6 to 9 spines. Lateral abdominal surface without pale bars 2

2. Abdominal pigmentation almost uniformly distributed, only slightly reduced laterally and ventrally. M.O.Q. length to posterior width ratio more than 1:2 ..... *Atrax eyrei*
—Abdominal pigmentation concentrated dorsally and posteriorly, lateral and ventral surfaces much paler. M.O.Q. length to posterior width ratio less than 1:2 ..... *Atrax flindersi*

KEY TO MALES

1. Tibia and metatarsus of leg 1 swollen. Tibia 1 with 2 ventral spines distally; metatarsus I with 25-30 ventral spines ..... *Atrax adelaidensis*
—Leg 1 unmodified. Tibia 1 with 6-10 ventral spines; metatarsus 1 with 14-16 ventral spines ..... *Atrax flindersi*

Atrax adelaidensis sp. n.
(Figs. 1-11, pl. 5)

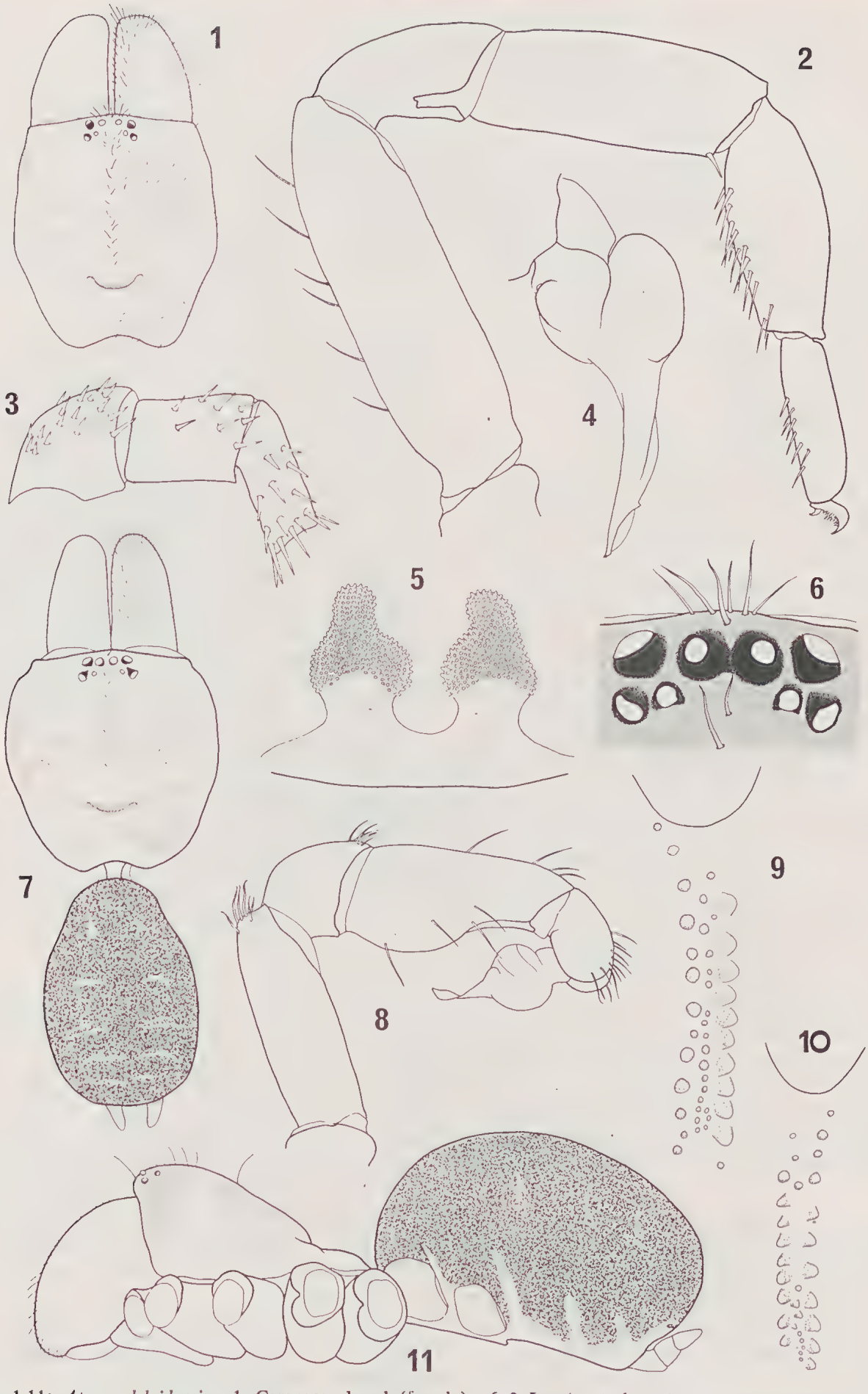
Diagnosis: Prodorsal surface of patella III with 18 to 26 spines, 8 to 11 on patella IV. Female abdomen pigmented dorsally and laterally but three to five pale bars on lower lateral surface of abdomen; ventral abdomen pale. Tibia I and metatarsus I and II of males swollen. Male metatarsus I with 25-30 spines ventrally. Middle third of ventral fang groove with few or no teeth in male.

Female—HOLOTYPE N1979146

Measurements (mm) and markings: Total length (including chelicerae) 18.98. Carapace length 6.78; width 5.88; height 3.35. Abdomen length 9.30; width 6.40. Colour pattern—Carapace dark glossy brown-black, sparsely haired. Black pigment around eyes. Dorsal and lateral surfaces of abdomen dark maroon-brown. Ventrally and above the spinnerets pigmentation greatly reduced. Three to five pale bars extend from ventral surface up onto darkly pigmented lateral surface. Above spinnerets, small sector of pigmented cuticle cut off by narrow semi-circular band of non-pigmented cuticle. Abdominal cuticle finely rugose, depressed intervals between rugosities formed by numerous, small, non-pigmented, sub-circular to elongate depressions. Along dorso-lateral surfaces three pairs of pale markings, anterior pair roughly circular, posterior pairs thin, laterally elongated lines.

Cephalothorax: Eyes—Size (mm): AME 0.19, ALE 0.32, PLE 0.26, PME 0.17. Interdistances (mm); AME-AME 0.34, AME-ALE 0.24, ALE-PLE 0.23, PLE-PME 0.13, PME-PME 0.73, M.O.Q. length 0.51 mm; width, anterior 0.69 mm, posterior 0.91 mm. M.O.Q. length/posterior width ratio 1:1.78. Anterior eye row straight, width 1.67 mm. Posterior eye row recurved, width 1.68 mm. Carapace—longer than wide in ratio 1:0.87; raised in head region, height/length ratio 1:2.02. Fovea deep and strongly procurved, anterior margin smoothly curved. Chelicerae—inner margins of fang groove with 11 teeth (9 large) outer margin with 11 large teeth; centre of groove with 23 small teeth in single row, less regular apically and basally. Labium—wider than long in ratio 1.45:1, cuspules numerous. Maxillae—divergent with short, conical lobe apically. Cuspules numerous, few apically; serrula absent. Sternum—subcircular; length 3.81 mm, width 3.62 mm. Surface gently convex with thin cover of long and short hairs. Three pairs of sigilla, posterior pair large and oval, anterior pair very small, circular.

Legs: 4123. Length (mm): I 15.45; II 14.39; III 11.64; IV 15.57. Spination: I—metatarsus v 5-6, tarsus pv 3-8, rv 3-4, v 0-1; II—metatarsus p 1, v 5-7, tarsus pv 4-11, rv 3-5; III—patella pd 18-26, tibia p 7-8, r 2-3, metatarsus p 5-8, pd 2-4, rd 2-3, v 5-7, tarsus pv 10-13, rv 2-5; IV—patella pd 8-11, tibia p 2, metatarsus p 6-7, rd 0-2, v 6-7, tarsus pv 10-12. Trichobothria in single row on



FIGS. 1-11: *Atrax adelaidensis*. 1, Carapace, dorsal (female), x6; 2, Leg 1, retrolateral (male), x11; 3, Leg 3, prolateral (female): patella, tibia and metatarsus, x11; 4, Male copulatory organ, x20; 5, Female internal genitalia, dorsal, x20; 6, Eyes (female), x20; 7, Body, dorsal (male) x6; 8, Palp, prolateral (male), x6; 9, Tooth pattern in fang groove, left hand side (female), x20; 10, Tooth pattern in fang groove, right hand side (male), x20; 11, Body, side view (female), x6.

tarsus, bothria collariform. Superior tarsal claws with three to six pectinations, inferior claw smooth. Tarsal scopulae absent. Tarsal organ distal to trichobothria, a low circular mound with faintly sculpted, concentric grooves.

Abdomen: Spinnerets—Posterior lateral spinnerets: length 2.35-2.58 mm; width 0.79-0.82; ratio of length of apical, middle and basal segment 2.2: 1:1.6; basal separation 1.10 mm; terminal segment conical, longer than wide in ratio 1.95:1. Posterior median spinnerets: length 1.02; width 0.52 mm. Genitalia—a pair of spermathecae open ventrally into common copulatory bursa. Middle part of each spermatheca swollen.

Male—PARATYPE N1979145

Measurements (mm) and markings: Total length (including chelicerae) 16.1. Carapace length 5.92, width 5.58, height 2.71. Abdomen length 6.8, width 4.8. Colour pattern—similar to female except that the dorso-lateral abdominal markings more evident; lateral abdomen uniformly pigmented, no pale bars present.

Cepholothorax: Eyes—Size (mm): AME 0.23, ALE 0.32; PLE 0.23; PME 0.14. Interdistances (mm): AME-AME 0.17; AME-ALE 0.16; ALE-PLE 0.20, PLE-PME 0.11, PME-PME 0.69; M.O.Q. length 0.47 mm, anterior width 0.61 mm, posterior width 0.97 mm. M.O.Q. length/posterior width ratio 1:2.06. Anterior eye row slightly procurved, width 1.55 mm. Posterior eye row recurved, width 1.60 mm. Carapace—longer than wide in ratio 1:0.94. Raised in head region, height/length ratio 1:2.18. Chelicerae—inner margin of fang groove with 10-11 teeth (9 large): outer margin with 13 teeth (11-13 large); central groove with a row of 2-4 small teeth in apical third, none or reduced in central third, a row of 7-10 small teeth in basal third. Palp—distal prodorsal femur with 4-6 sinuous bristles; patella with 4-7 dorsal apical bristles. Embolic process of palpal bulb short and broad with well developed apical flange. Labium —wider than long in ratio 1:1.61, cuspules numerous. Sternum—length 3.63 mm, width 3.03 mm.

Legs: 1423 (or 4123). Length (mm): I 18.41 (19.30); II 17.55 (18.93); III 14.39 (15.35); IV 17.85 (19.60). Anterior legs modified, tibia I and metatarsus I swollen; metatarsus II weakly swollen. Tarsi weakly scopulate. Spination: I—tibia v 1-2, metatarsus p 0-2, v 25-30, tarsus pv 10-12, rv 7-11, v 0-2; II—femur d 0-1, patella r 0-1, tibia p 0-1, v 1-2, metatarsus p 0-1, r 0-2, v 12-16, tarsus pv 10-16, rv 6-11, v 0-1; III—patella pd 18-23, tibia pd 9-11, r 3, v 1-7, metatarsus p 8-13, pd 0-4, r 1-6, rd 2-5, v 8-14, tarsus p 12-16, r 0-2, rv 6-9, v 0-1; IV—femur d 4, patella pd 7-8, tibia p 2-3, r 2-4, d 1-2, v 2-4, metatarsus p 8, rd 1-2, v 8-12, tarsus p 14-17, rv 6-11, v 0-1. Single row of 3 to 5 weak bristles on dorsal surfaces of femora I, II, IV.

Abdomen: Spinnerets—posterior lateral spinnerets; length 2.60 mm; maximum width 0.56 mm; ratio of length of apical, middle and basal segments 1.55:1:1.79; basal separation 0.95 mm; apical segment conical, length/width ratio 2.82:1. Posterior median spinnerets; length 0.77 mm, width 0.31 mm.

Material examined: Holotype female (N1979146 S.A. Mus. coll.), Hackney, Adelaide, S.A. 16.11. 1973, J. Batt; burrow in sloping, littered ground on banks of Torrens River. Paratype male (N1979145 S.A. Mus. coll.), St. Peters C.G.S., Adelaide, S.A. 3.6.1971, D. Edwards Paratype female (KS 4511 Aust. Mus. coll.), Beefacres Recreation Reserve, S.A., 16.11.1973, N. Miles; found in damp sandy soil under tree stump. Paratype male (KS 4512 Aust. Mus. coll.), Belair, Mt. Lofty Range, S.A. 24.5.1972. Two paratype males (N1979147, N1979148 S.A. Mus. coll.), Clare, S.A. 5.8.1979. Paratype female (N1979149 S.A. Mus coll.), Rostrevor, Nr. Adelaide, S.A., May 1974, B. Brewer; in burrow, shaded alluvial soil by creek. Juvenile, Hahndorf, Mt. Lofty Range, S.A.

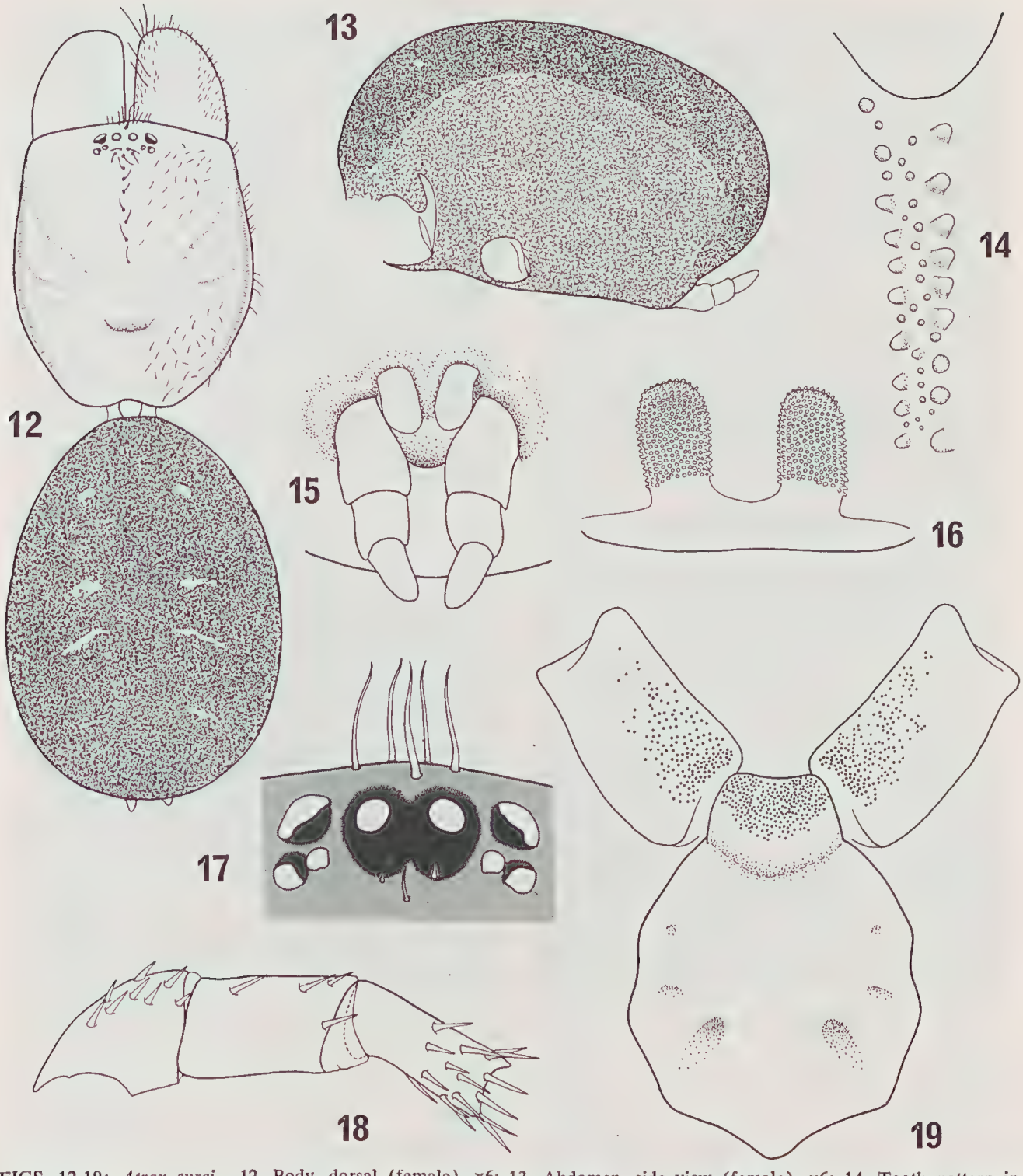
Atrax eyrei sp. n.
(Figs. 12-19)

Diagnosis: Prodorsal surface of patella III with 8 to 9 spines; 0 to 1 on patella IV. Abdominal pigmentation almost uniform, only slightly paler laterally and ventrally. Posterior median eyes widely separated; M.O.Q. length/posterior width ratio much greater than 1:2.

Female—HOLOTYPE KS 4509

Measurements (mm) and markings: Total length (including chelicerae) 18.14. Carapace length 6.62; width 5.93; height 3.38. Abdomen length 8.1; width 5.9. Colour pattern—Carapace dark, glossy brown-black, sparsely haired. Black pigment around eyes. Abdomen dark maroon-brown dorsolaterally, ventral surface only slightly paler. Abdominal cuticle finely rugose with small, subcircular to elongate nonpigmented depressions between rugosities. Dorsolateral abdominal surfaces with four pairs of non-pigmented markings, anterior pair sub-circular, remainder laterally elongate.

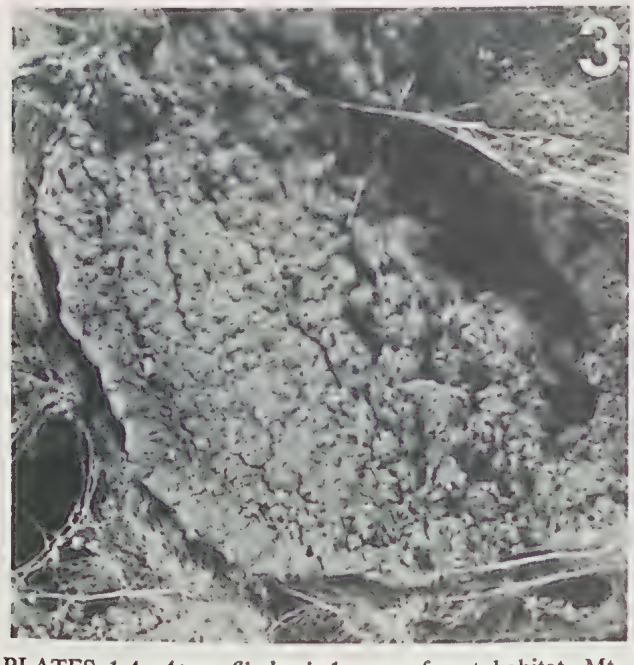
Cephalothorax: Eyes—Size (mm): AME 0.23, ALE 0.30, PLE 0.19, PME 0.13. Interdistances: AME-AME 0.28, AME-ALE 0.20, ALE-PLE 0.18, PLE-PME 0.06, PME-PME 0.91. M.O.Q. length 0.47, anterior width 0.71, posterior width 1.21. M.O.Q. length/posterior width ratio 1:2.57.

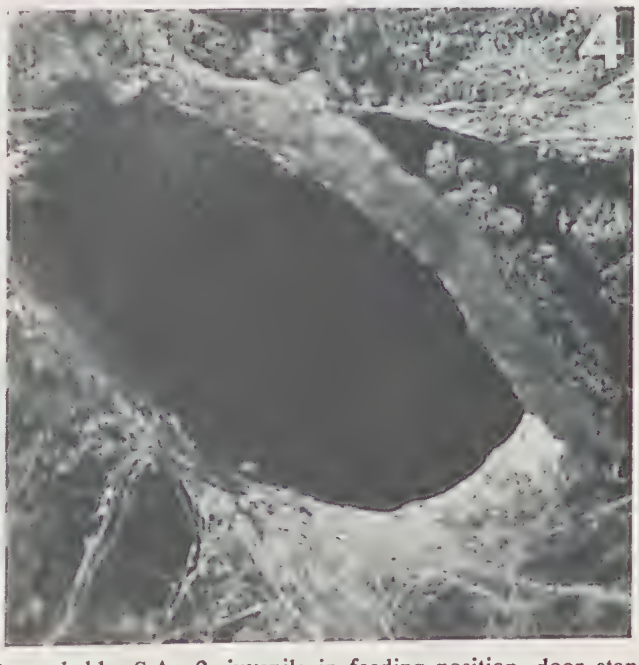


FIGS. 12-19: *Atrax eyrei.* 12, Body, dorsal (female), x6; 13, Abdomen, side view (female), x6; 14, Tooth pattern in fang groove, left hand side (female), x20; 15, Spinnerets, ventral (female), x20; 16, Female internal genitalia, dorsal, x20; 17, Eyes, dorsal (female), x20; 18, Leg 3, prolateral (female): patella, tibia and metatarsus, x 11; 19, Maxillae, labium and sternum, ventral (female), x6.

Anterior eye row straight, width 1.62 mm; posterior eye row recurved, width 1.61 mm. Carapace—longer than wide in ratio 1:0.90; raised in head region, height/length ratio 1:1.96. Fovea procurved, anterior margin slightly indented on each side of midline. Chelicerae—inner margin of fang groove with 13-14 teeth (10 large), outer margin with 10 large teeth, central groove with 20-23 small teeth in irregular row. Labium—wider than long in ratio 1.45:1, numerous cuspules. Maxillae—divergent with short conical lobe apically, serrula absent; cuspules numerous, few apically. Sternum—subcircular; length 3.90 mm, width 3.65 mm. Surface gently convex with thin covering of long and short hairs. Three pairs of sigillae, posterior pair large and oval, anterior pair very small, circular.

Legs: 4123. Length (mm): I 16.02; II 14.40; III 12.41; IV 16.03. Spination: I—metatarsus v 8, tarsus pv 3, rv 5, v 1; II—metatarsus p 0-1, v 9,





PLATES 1-4, *Atrax flindersi*. 1, open forest habitat, Mt. Remarkable, S.A.; 2, juvenile in feeding position, door standing open, silk trip lines radiating from burrow rim; 3-4, surface door of juvenile, 3, closed; 4, open.

tarsus pv 4-5, rv 4; III—patella pd 8-9, tibia p 4, r 1-2, metatarsus p 4-5, pd 2, rd 1-2, v 9, tarsus pv 8-9, rv 4; IV—patella pd 0-1, tibia p 1, metatarsus p 2, v 5-8, tarsus pv 7-9, rv 2. Trichobothria in single row on tarsus, bothria collariform. Superior tarsal claws with 5-6 pectinations, inferior claws smooth or with 1 pectination. Tarsal scopulae absent.

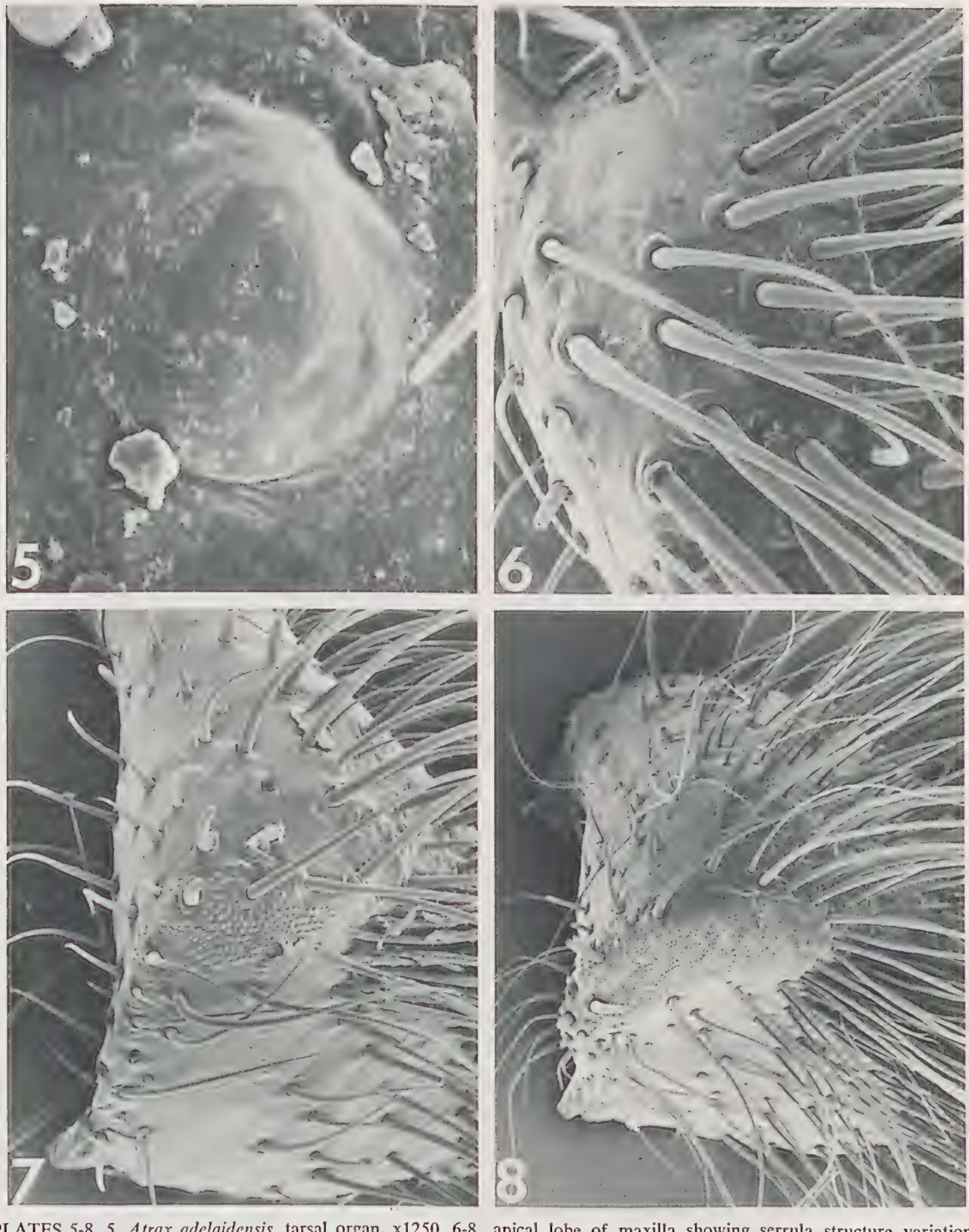
Abdomen: Spinnerets—posterior lateral spinnerets: length 2.67-2.72 mm; width 0.90-0.94 mm; ratio of length of apical, middle and basal segments 1.08:1:1.60; basal separation 1.30 mm; terminal segment conical, longer than wide in ratio 1.86:1. Posterior median spinnerets: length 0.94 mm; width 0.47 mm. Genitalia—pair of short, broad spermathecae opening ventrally into a common copulatory bursa.

Material examined: Holotype female (KS 4509 Aust. Mus. coll.), 6.5 km south of Coulta, Eyre Peninsula, S.A. 18.12.1952. B. Y. Main (cat. no. 52/600). Paratype female (KS 4510 Aust. Mus. coll.), between Coulta and Wangary, Eyre Peninsula, S.A., 18.12.1952. B. Y. Main (cat. no. 52/611). Juvenile male, Nr. Port Lincoln, Eyre Peninsula, S.A., 16.12.1952, B. Y. Main (cat. no. 52/540).

Atrax flindersi sp. n.

(Figs. 20-30, pls 1-4, 6)

Diagnosis: Prodorsal surface of patella III with 5 to 10 spines; 0 to 3 on patella IV. Abdominal pigmentation mainly dorsal; lateral and ventral surfaces paler. Femur I of male with 7-9 spines dorsally, femur II of male with 5-7. Tibia I of male with 6-10 ventral spines, tibia II of male with 8-10.



PLATES 5-8. 5, *Atrax adelaidensis*, tarsal organ, x1250. 6-8, apical lobe of maxilla showing serrula structure variation in three species of funnel web spider; 6, *A. flindersi* (serrula absent), x165; 7, *A. robustus*, x90; 8, *A. versutus*, x60.

Female—HOLOTYPE KS 983

Measurements (mm) and markings: Total length (including chelicerae) 20.02. Carapace length 6.90; width 6.12; height 3.37. Abdomen length 9.1; width 7.3. Colour pattern—carapace dark glossy brown-black, sparsely haired. Black pigment around eyes. Abdominal pigmentation dark maroon-brown dorsally, pigmented area narrow anteriorly, broader posteriorly. Lateral and ventral abdomen very lightly pigmented and tinged with pink. Abdomen cuticle finely rugose with small subcircular to elongate non-pigmented depressions between rugosities. Dorso-lateral abdominal surfaces with four pairs of non-pigmented markings, anterior pair subcircular, remainder elongated and rather indistinct.

Cephalothorax: Eyes—Size (mm): AME 0.23, ALE 0.34, PLE 0.31, PME 0.18. Interdistances: AME-AME 0.27, AME-ALE 0.25, ALE-PLE 0.26, PLE-PME 0.11, PME-PME 0.78. M.O.Q. length 0.65, anterior width 0.67, posterior width 1.12. M.O.Q. length/posterior width ratio 1:1.72. Anterior eye row straight, width 1.65 mm; posterior eye row recurved, width 1.80 mm. Carapace—longer than wide in ratio 1:0.89; raised in head region, height/length ratio 1:2.01. Fovea deep and strongly procurved, anterior margin with broad shallow indentation centrally. Chelicerae—inner margin of fang groove with 14-16 teeth (12-15 large); outer margin with 15-18 teeth (12 large); central groove with 23-27 small teeth in irregular row, divided into two rows apically. Labium—wider than long in ratio 1.40:1, numerous cuspules. Maxillae—divergent, apically with short conical lobes, serrula absent; cuspules numerous, few apically. Sternum—subcircular to oval; length 4.04 mm, width 3.66 mm. Surface gently convex with thin covering of long and short hairs. Three pairs of sigilla, posterior pair large and oval. Anterior pair very small, circular.

Legs: 4123. Length (mm): I 16.33; II 14.93; III 13.36; IV 16.79. Spination: I—metatarsus v 7-9, tarsus pv 4-5, rv 5-6; II—metatarsus p 0-1, v 8-10, tarsus pv 4-5, rv 4-8; III—patella pd 5-10, tibia p 4, r 1-2, v 0-1, metatarsus p 2-5, pd 2-3, rd 2, v 7-10, tarsus pv 10-14, rv 4, v 0-1; IV—patella pd 0-2, tibia p 0-1, v 0-1, metatarsus p 1-4, rd 0-1, v 4-8, tarsus pv 6-15, rv 0-3. Superior tarsal claws 5-7 pectinations, inferior claws smooth. Tarsal scopulae absent. Tarsal organ distal to trichobothria, low circular mound with faint concentric grooves.

Abdomen: Spinnerets—posterior lateral spinnerets; length 3.53 mm; width 1.02 mm; ratio of length of apical, middle and basal segments 1.78:1:1.62; basal separation 1.48 mm; terminal segment conical, longer than wide in ratio 2.56:1. Posterior median spinnerets: length 0.94 mm, width 0.47 mm. Genitalia—a pair of rather slender spermathecae, terminally swollen, opening ventrally into common copulatory bursa.

Male—PARATYPE KS 980

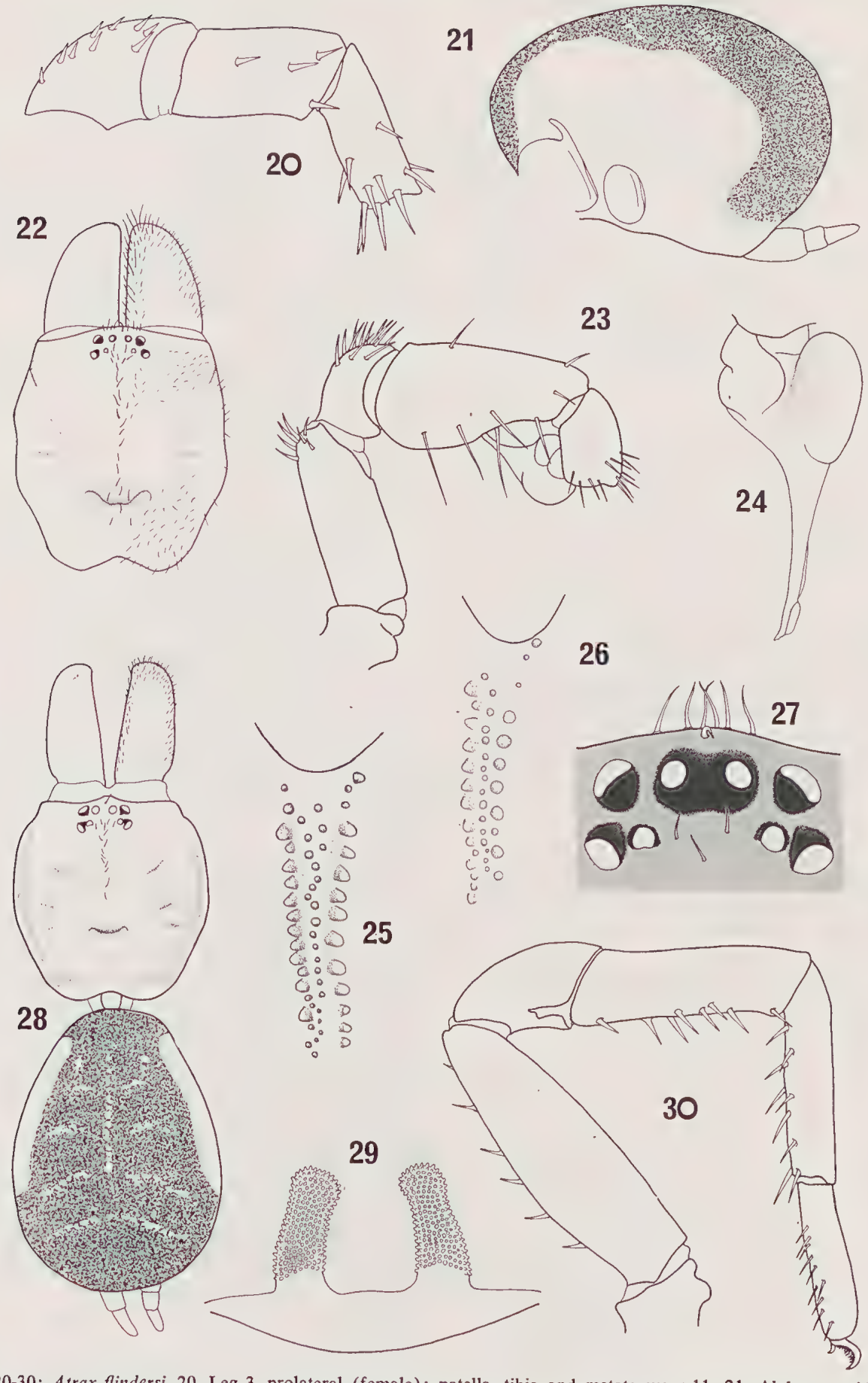
Measurements (mm) and markings: Total length (including chelicerae) 16.80. Carapace length 6.23; width 6.29; height 3.06. Abdomen length 7.50; width 5.70. Colour pattern—as for female; paired abdominal markings slightly more emphatic.

Cephalothorax: Eyes—Size (mm): AME 0.26, ALE 0.35, PLE 0.23, PME 0.15. Interdistances (mm): AME-AME 0.26, AME-ALE 0.12, ALE-PLE 0.24, PLE-PME 0.12, PME-PME 0.82. M.O.Q. length 0.58, anterior width 0.74, posterior width 1.18. M.O.Q. length/posterior width ratio 1:2.03. Anterior eye row straight, width 1.59 mm. Posterior eye row recurved, width 1.64 mm. Carapace—slightly wider than long in ratio 1:0.99. Raised in head region, height/length ratio 1:2.04. Fovea deep, procurved, anterior margin smoothly curved. Chelicerae—inner margin of fang groove with 12 teeth (10-12 large), outer margin with 14-15 teeth (12-13 large), central groove with 18-19 small teeth in single row. Palp—femur with 7 prodorsal, apical spines; patella with 14 dorsal, apical spines. Embolic process of palpal bulb straight and slender with well developed apical flange. Labium—wider than long in ratio 1.54:1. Sternum—subcircular; length 3.46 mm; width 3.26 mm. Sigillae as in female but placed closer to lateral margins and anterior sigilla much more distinct.

Legs: 4123. Length (mm): I 19.46; II 18.24; III 17.82; IV 21.39. First and second legs unmodified. Tarsi of legs III and IV mildly swollen. Tarsal scopulae present, strongly developed on legs II, III and IV. Spination: I—femur p 0-2, d 7-9, tibia p 0-1, v 6-10, metatarsus p 0-2, v 12-15, tarsus pv 8-9, rv 9-12, v 1-3; II—femur d 5-7, tibia v 8-10, metatarsus v 12-13, tarsus pv 9-10, rv 8-10, v 0-1; III—femur d 0-1, patella pd 5-8, tibia p 4-7, r 1-4, d 1-4, d 1, v 4-6, metatarsus p 2-8; r 2-3, rd 2-3, v 11-15, tarsus p 8-12 r 0-2, rv 8-14; IV—femur d 5-6, patella p 0-3, tibia p 1-4, r 3-5, d 0-3, v 4-6, metatarsus p 3-5, re 0-2, v 11-15, tarsus p 9-15, rv 8-11.

Abdomen: Spinnerets—Posterior lateral spinnerets: length 3.30 mm; width 0.71 mm; ratio of length of apical, middle and basal segments 1.12:1:1.24; basal separation 1.40 mm; terminal segment a slender cone, longer than wide in ratio 3.49:1. Posterior median spinnerets cylindrical; length 0.91 mm, width 0.36 mm.

Material examined: Holotype female (KS 983 Aust. Mus. coll.), Mt. Remarkable (lower slopes), 3 km, north of Melrose, Flinders Range, S.A., 23.4.1973, M. and G. Gray. Dry open and eucalypt forest, burrow with side passage in littered riparian slope; juveniles in side passage. Paratype male (KS 980 Aust. Mus. coll.), Mt. Remarkable (lower slopes), 3 km north of Melrose, Flinders Range, S.A., 25.4.1973, M. and G. Gray; pitfall trap in dry open forest on southern eastern slope. Paratype males (KS 979 and KS 985 Aust. Mus. coll.) and female (KS 981 Aust. Mus. coll.), Mt. Remarkable (lower slopes), 3 km north of Melrose, Flinders Range, S.A., March-April 1973, M. and G. Gray; dry open euclaypt forest, sloping ground with medium-heavy litter cover.



FIGS. 20-30: *Atrax flindersi*. 20, Leg 3, prolateral (female): patella, tibia and metatarsus, x11; 21, Abdomen, side view (female), x6; 22, Carapace, dorsal (female), x6; 23, Palp, prolateral (male), x11; 24, Male copulatory organ, x20; 25, Tooth pattern in fang groove, right hand side (female), x20; 26, Tooth pattern in fang groove, right hand side (male), x20; 27, Eyes, dorsal (female), x20; 28, Body, dorsal (male), x6; 29, Female internal genitalia, dorsal, x20; 30, Leg 1, retrolateral (male), x11.

BEHAVIOURAL OBSERVATIONS ON *ATRAX FLINDERSI*

Field observations

Summer collections of *A. flindersi* were made on riparian slopes in the summer-dry, open eucalypt forest habitats of the Mt. Remarkable area (Plate 1). The retreat is a ground-burrow consisting of a main shaft plus a side chamber closed by a door (Fig. 31). The burrow has a single entrance which is hidden amongst the well-developed litter layer of the forest floor. The burrow may be sited in an open situation or in the shelter of a grass tussock, log or stump. This retreat structure contrasts markedly with that typical of many eastern members of the genus occupying wetter forest habitats (Gray 1978).

The entrance to the adult burrow consists of a silk collar which in *A. flindersi* is produced around one side to form a short cowl-like structure which lies limply across the entrance partially occluding it. The silk of both collar and cowl is well disguised by attached litter and fine soil particles.

The silk lining of the main shaft is entire and closely adherent to the soil walls. Total burrow depth varied from 21 to 25 mm; burrow diameter varied from 1-1.5 cm near the entrance to 2-2.5 cm in the end chamber. The general inclination of the burrow is at 90° to the ground slope, though the end chamber below the level of the side chamber may be less steeply inclined.

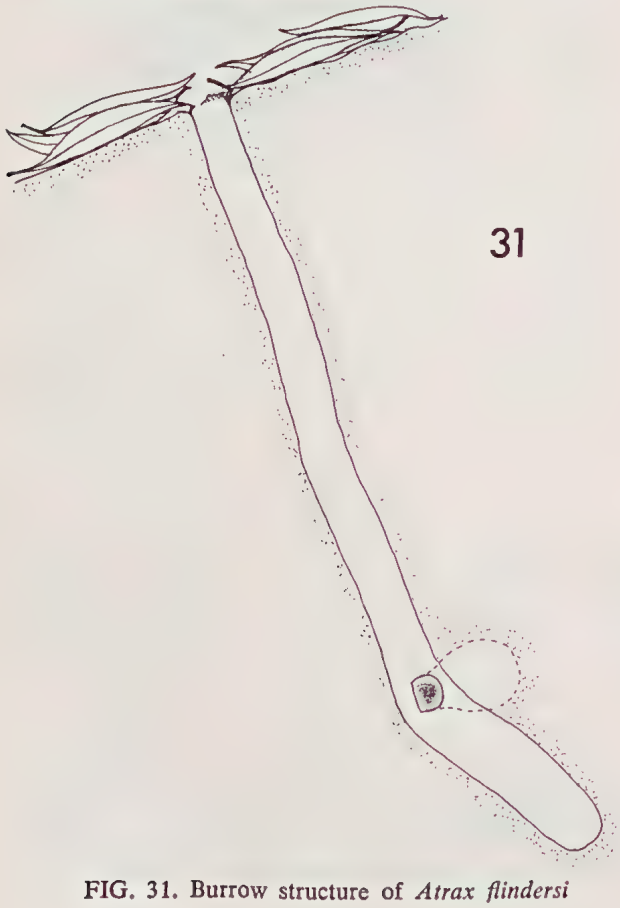


FIG. 31. Burrow structure of *Atrax flindersi*

The silk-lined, flask-shaped side chamber (length 3-4.5 cm; width 2-2.5 cm in adult burrows) was placed between three-quarters and four-fifths of the way down the burrow of adult specimens. In the burrows of juveniles the side chamber may be only half-way or even less down the burrow. The side chamber is closed by a strong, externally concave, soil trapdoor, hinged vertically (diameter 0.85-1.5 cm in adult burrows). The usual orientation of the side chamber was slightly upslope, but this was not invariable. A shallow excavation in the wall of the main shaft at the level of the trapdoor probably provides space for manoeuvring during door opening operations.

The functions of the side chamber seem mainly concerned with the provision of a secure refuge against predators, particularly when moulting, and a protective brood chamber for the eggs and spiderlings. Several *Atrax* burrows were found to contain occupants which could represent predators—a centipede, a large carabid beetle and a spider—the latter belonged to the genus *Aname* and was found with the remains of the presumed original occupant. One burrow contained a brood of 21 spiderlings in the side chamber. The need to function as a brood chamber during the hot summer months could account for the trend suggesting that adult side chambers are found at greater depths relative to total burrow depth than those of juveniles; brood chamber function would require long term constancy of high humidity—moderate temperature conditions which would not be so critical for the temporary predator/moulting refuge function which must be the primary role of the shallower side chamber of juvenile burrows.

Morphological adaptations to aridity are not readily apparent in any of the *adelaidensis* species. Consequently, in summer-drought regions such as the Flinders Range the construction of a relatively deep, vertical ground burrow has obvious advantages in avoiding desiccation and overheating. Soil characteristics may also be significant, particularly in relation to their water-holding ability which directly influences soil and burrow air-water humidity. The burrows of *A. flindersi* were excavated in a yellow-grey, gritty loam. Evidence from trapdoor spider burrow studies indicates that such soil would require severe surface drying conditions to render the soil air significantly undersaturated below 10 cm from the surface (Gray 1969). The surface litter cover would provide a further cushioning effect against environmental drying.

Laboratory observations

Fifteen juveniles (probably second instar) taken from the side chamber of a burrow in the Mt. Remarkable area were set up individually in glass jars with 10 cm depth of lightly littered soil. All

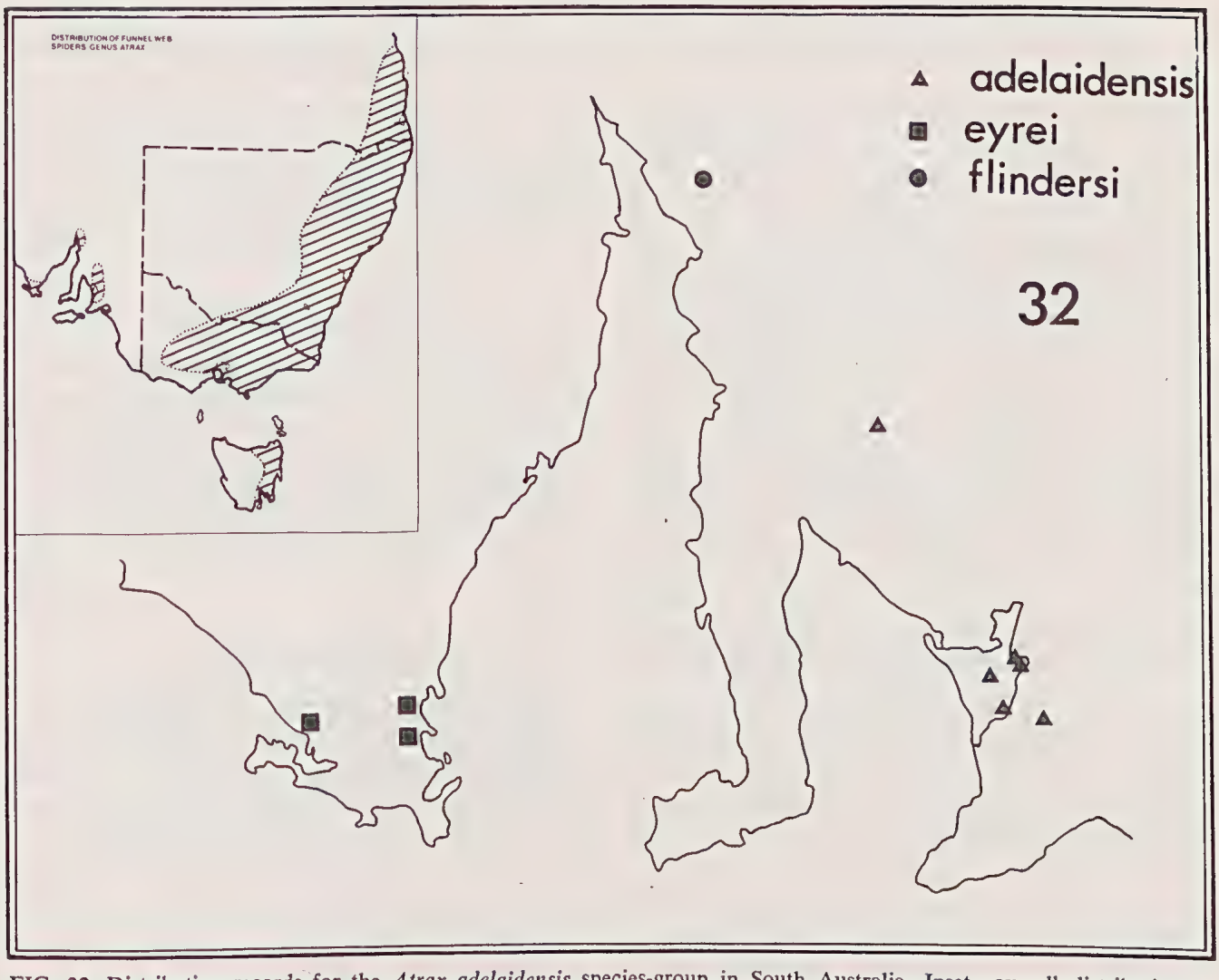


FIG. 32. Distribution records for the *Atrax adelaidensis* species-group in South Australia. Inset—overall distribution of the genus *Atrax*.

juveniles excavated small burrows and twelve of them constructed flap-like, but quite rigid, soil trapdoors closing the surface burrow entrances (Plate 2, 3). The remainder constructed an indefinite soil-silk entrance mound. When hunting, the juveniles would prop the door wide open at an angle of 70-100° and sit in the burrow mouth with the tarsi of the palps and first two pairs of legs resting on the burrow rim (Plate 4). Some sheet-like silk was placed on the ground around the burrow entrance, usually radiating outwards as prey trip-lines. In catching prey the spiderlings were seen to fully emerge from the burrow up to a distance of 2 cm. Examination of these burrows revealed that no side chamber was present, the burrow consisting of a simple, vertical shaft. The discovery of surface door building behaviour in *A. flindersi* spiderlings is interesting in view of its absence in the adults and larger juveniles. However, in the context of the environmental conditions that the juveniles face, adaptive advantages can be seen. The major advantages would seem to be that the microclimate within a shallow burrow closed by a surface door is likely to be more stable than that found within an open or partially closed burrow; and in the absence of a side chamber refuge, the surface door may serve to decrease predation on spiderlings. The burrows of larger juvenile spiders kept in captivity showed no sign of a surface door, a mixture of soil and silk usually partially closing the entrance leaving only a small opening to one side or none at all. A side chamber with door was always present in these burrows.

The initial stages of burrowing activity by some of these juveniles were observed. The litter adjacent to the burrow site was silked together and drawn inwards. The soil surface to be excavated was thinly silked over, a process repeated with each phase of digging, and the chelicerae used to loosen the soil. Both chelicerae and palps combined to scrape up and carry away the soil as silk-impregnated bundles which were initially deposited (and tamped down by the palps) just outside the burrow lip. Frequent 360° traverses were made with the spinnerets about the lip area of the burrow so building up a soil-impregnated silk collar attached to the surrounding

litter. This collar was periodically raised slightly by the palps and first legs and the whole jerked in centrally.

At this stage a shallow inclined burrow approximately 2 cm deep and 1.5 cm wide had been excavated. A second opening or "window", about half the size of the original entrance, was then made in the thin roof of the burrow; this "window" apparently provided room for manoeuvring while excavating the bottom of the burrow, the spider's abdomen being protruded out of it during turning and digging operations. Subsequent activity took place entirely within the burrow. Soil was progressively added to the internal margins of both entrance and window until the latter was completely closed over. The entrance was eventually reduced to a small irregular hole 2-3 mm wide located near the lower edge of the original entrance. This location arose because the direction of deposition of soil proceeded from the upper toward the lower margin of the entrance. The soil-impregnated silk curtain so formed over the burrow entrance can be seen to have affinities both with the cowl-like entrance structure noted in the field situation and the soil door built by captive second instar juveniles.

ACKNOWLEDGEMENTS

My thanks to Dr. B. Y. Main for the loan of specimens from the Eyre Peninsula and locality data for the Melrose area. I am grateful to Mr. D. C. Lee of the South Australian Museum for his co-operation in the provision of facilities and the loan of material. Drawing assistance was provided by G. E. J. Gray.

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THE PSOCOPTERA (INSECTA) OF SOUTH AUSTRALIA

by

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ABSTRACT

SMITHERS, C. N., 1982. The Psocoptera (Insecta) of South Australia. *Rec. S. Aust. Mus.* **18** (20): 453-491.

The number of Psocoptera known from South Australia is increased from 8 to 45, including 16 new species and 21 new records for the State. The fauna appears to be predominantly associated with bark and dried leaves as opposed to green foliage. The relationships of the fauna are discussed briefly within the context of present records of the Australian fauna.

INTRODUCTION

Two significant recent collections of Psocoptera from South Australia have prompted a detailed study of all material available from this area the results of which are presented here.

The first Psocoptera from South Australia were described by McLachlan (1866). He described *Psocus pallipes* McLachlan from Adelaide, transferring it to *Propsocus* in a postscript to the same paper. It has since been recorded from Western Australia, Queensland and New South Wales. He also described *Psocus striatifrons* McLachlan from "Australia meridionali", transferring it immediately to *Stenopsocus* Hagen. This species has not been recorded again and it is possible that it may not be South Australian even if it does occur elsewhere in southern Australia. The type locality is not precisely known. *Stenopsocus* is a Palaearctic and Oriental genus with one species in New Guinea and eastern Australia which has been found as far south as northern New South Wales. *S. striatifrons* is certainly not the same species. Detailed study of the type of *S. striatifrons* is necessary to clarify its status and confirm its generic position. Banks (1939) described *Zelandopsocus sinuosus* Banks from "Mt. Lofty Range". This species is now placed in *Austropsocus* Smithers and has been recorded from Tasmania, Victoria, Australian Capital Territory, New South Wales and Queensland. Smithers (1964a) recorded the widespread *Lepinotus reticulatus* Enderlein and *Psyllipsocus ramburii* Selys-Longchamps from caves in South Australia and *Phlotodes australis* (Brauer) from several localities (Smithers 1964b). Thornton and New (1977) recorded *Haplophallus bundoorensis* New and *H. medialis* Thornton and New from South Australia. The former is known from Victoria, Queensland and New South Wales and the latter from New South Wales, Australian Capital Territory and Victoria. So, by 1977 eight species had been recorded from South Australia.

This paper is based on collections in the Australian Museum and the South Australian Museum. These include 41 species, of which four have already been recorded from South Australia. Four of the recorded species are not represented in the present material. 21 are new records for the State (marked with an asterisk in the list below) and 16 are new species. In all, 45 species (including *S. striatifrons*) are now known from South Australia.

The Psocoptera so far recorded from South Australia are nearly all inhabitants of bark or dead leaves; there seem to be very few species on green foliage. Precise habitat information is, however, available for only a small proportion of the material. The species which may be associated with green foliage are *Caecilius semifuscatus* (Tillyard), *Stenopsocus striatifrons* (if it is a *Stenopsocus*) and *Cladioneura punctata* sp. n. although even these cannot be confirmed as inhabitants of fresh leaves. It seems unlikely that the main method of collecting, by beating, would give samples biassed toward bark dwellers as opposed to inhabitants of green leaves. The fauna as so far known seems, therefore, to be poor in inhabitants of green leaves.

Echinopsocus grayi sp. n., *Pachytroctes rugosus* sp. n. and *Sphaeropsocopsis recens* (Hickman) are leaf litter insects. *Echmepteryx* (*Loxopholia*) *brunnea* Smithers is an inhabitant of twigs and smaller branches. The two species of Trogiidae, *Cerobasis guestfalica* (Kolbe) and *Lepinotus reticulatus* and also *Psyllipsocus ramburii* are very widespread domestic species which have all been taken in outdoor habitats, the last two being known also from caves. *Lachesilla pedicularia* (L.) has been recorded from several parts of the world. In Europe it is an inhabitant of trees and shrubs and is often found in homes. The only South Australian record is from packing straw from England. The two species of Ectopsocidae, *Ectopsocus californicus* (Banks) and *E. cetratus* Smithers, are inhabitants of dried leaves either on plants or as leaf litter as are *Pentacladus eucalypti* Enderlein and *Propsocus pallipes*. *Mesopsocus reticulatus* sp. n. is the first species of the family to be recorded from Australia. Several

members of this family in Africa occur in fairly dry habitats on the twigs of shrubs and the European species are found on bark of branches and twigs. The most important family of bark dwelling psocids is the Psocidae. The family is well represented in South Australia, comprising about 30% of the psocopteran fauna so far known. The two myopsocids, *Phlotodes australis* and *Ph. hickmani* (Smithers), feed on algae and fungi on bark; the former is very common on damp suburban paling fences.

Until the fauna of the whole of the continent is better known only tentative comments can be made on the relationships of the South Australian fauna as a whole although a few elements can be clearly discerned. There is a worldwide element, represented by such species as *Cerobasis guestfalica*, *Lepinotus reticulatus* and *Psyllipsocus ramburii* which have probably established themselves independently of human influence, although they are also found in domestic situations. *Ectopsocus californicus* and *Lachesilla pedicularia* are similarly very widespread species well able to establish themselves in new areas. There is an element composed of Australasian species, such as *Caecilius semifuscatus*, *Peripsocus maoricus* (Tillyard), *Propsocus pallipes*, *Pentacladus eucalypti*, *Phlotodes australis* and the philotarsids, which are widespread in coastal regions of Australia and which, in some cases, have ranges which include New Zealand and Norfolk Island. To what extent there has been human influence in the overseas distributions is not known but such species as *Ph. australis* could easily be carried on timber. Together with these species can be included those which have a more restricted southern and eastern Australian distribution such as *Echmepteryx brunnea* Smithers, *Peripsocus edwardsi* New, *P. hickmani* New, *Spilopsocus ruidis* Smithers and *Tanystigma tardipes* (Edwards). There appear to be two other elements occurring in South Australia one of which has affinities with Western Australia, including species such as *Lasiopsocus michaelseni* Enderlein and *Ectopsocus cetratus*, while the other has affinities in an easterly direction with Victoria and Tasmania, represented by such species as *Phlotodes hickmani*, *Spilopsocus masseyi* New and members of the *Blaste macrops* species group. Finally, there is the interesting species *Sphaeropsocopsis recens* which is known from Tasmania and South Australia and which appears to have close relatives only in South America, Angola and in Baltic amber. *Mesopsocus reticulatus* is an anomalous species in that the genus is known from many parts of the world but has not yet been mentioned in records for other parts of Australia. Its occurrence in South Australia places it in an unusual, isolated position zoogeographically.

TAXONOMIC ACCOUNT OF SOUTH AUSTRALIAN PSOCOPTERA

Smithers (1970, p. 372 *et seq.*) has given a key to the families of Australian Psocoptera. In that key the Mesopsocidae (not previously recorded from Australia) would run to couplet 6. As it has glabrous wings *Mesopsocus* will run to the Psilopsocidae, a family not yet recorded for South Australia. *Mesopsocus* differs from psilopsocids in having a tall areola postica and clear, hyaline wings; the psilopsocids have a shallow areola postica and darkly patterned wings.

LIST OF SPECIES OF PSOCOPTERA KNOWN FROM SOUTH AUSTRALIA

(* New records for South Australia. ** South Australian species not represented in present material).

LEPIDOPSOCIDAE
Echinopsocus grayi sp. n.
**Echmepteryx* (*Loxopholia*) *brunnea* Smithers

TROGIIDAE
**Cerobasis guestfalica* (Kolbe)
***Lepinotus reticulatus* Enderlein

PSYLLIPSOCIDAE
***Psyllipsocus ramburii* Selys-Longchamps

PACHYTROCTIDAE
Pachytroctes rugosus sp. n.

SPHAEROPSOCIDAE
**Sphaeropsocopsis recens* (Hickman)

CAECILIIDAE
**Caecilius semifuscatus* (Tillyard)

STENOPSOCIDAE
***Stenopsocus striatifrons* (McLachlan)

LACHESILLIDAE
**Lachesilla pedicularia* (L.)

ECTOPSOCIDAE
**Ectopsocus californicus* (Banks)
**Ectopsocus cetratus* Smithers

PERIPSOCIDAE
**Peripsocus edwardsi* New
**Peripsocus maoricus* (Tillyard)
**Peripsocus hickmani* New
Peripsocus notialis sp. n.
Peripsocus hollowayi sp. n.

PSEUDOCAECILIIDAE
Cladioneura punctata sp. n.

ELIPSOCIDAE
**Pentacladus eucalypti* Enderlein
Propsocus pallipes (McLachlan)
**Spilopsocus masseyi* New
**Spilopsocus ruidis* Smithers

PHILOTARSIDAE
***Austropsocus sinuosus* (Banks)
**Haplophallus guttatus* (Tillyard)
Haplophallus bundoorensis New
Haplophallus medialis Thornton and New
**Haplophallus sinus* Thornton and New
**Aaroniella rawlingsi* Smithers

MESOPSOCIDAE
Mesopsocus reticulatus sp. n.

PSOCIDAE
**Lasiopsocus michaelseni* Enderlein
Lasiopsocus dicellus sp. n.
Blaste macrops sp. n.
Blaste magnifica sp. n.
Blaste angusta sp. n.
**Ptycta umbrata* New
**Ptycta glossoptera* New
Ptycta longipennis sp. n.
Ptycta hollowayae sp. n.
**Tanystigma tardipes* (Edwards)
Tanystigma elongata sp. n.
Tanystigma bifurcata sp. n.
Psocidus mouldsi sp. n.
Psocidus parilla sp. n.

MYOPSOCIDAE
Phlotodes australis (Brauer)
**Phlotodes hickmani* (Smithers)

KEY TO ADULT PSOCOPTERA FROM SOUTH AUSTRALIA

1 Antennae with more than 20 segments, never secondarily annulated. Tarsi 3-segmented. Pterostigma not thickened, or absent. Paraprocts with strong posterior spine 3
Antennae usually with 13 segments, if 15- to 17-segmented then some segments are secondarily annulated. Tarsi 2- or 3-segmented. Pterostigma thickened or not. Paraprocts without posterior spine 2

2 (1) Antennae 12- to 17-segmented, some secondarily annulated. Tarsi 3-segmented. Pterostigma not thickened 5
Antennae usually 13-segmented. Tarsi 2- or 3-segmented, if latter then flagellar segments not secondarily annulated. Pterostigma thickened .. 6

3 (1) Head long and vertical. Maxillary palp without sensillum on inner side of second segment. Cu_2 and IA end together at wing margin (i.e. nodulus present) (Psyllipsocidae) ..... *Psyllipsocus ramburii*
Head short. Maxillary palp with sensillum on inner side of second segment. Cu_2 and IA end separately at wing margin (i.e. no nodulus) 4

4 (3) Claws with preapical tooth. Body and wings bearing scales (Lepidopsocidae) 18
Claws without preapical tooth. Body and wings not scaly (Trogiidae) 19

5 (2) Wings, when present, flat, with complete venation. In apterous and alate forms eyes situated near vertex (Pachytroctidae) .... *Pachytroctes rugosus*
Wings, when present, with incomplete venation, curved, elytriform. Eyes situated well below vertex (Sphaeropsocidae) ..... *Sphaeropsocopsis recens*

6 (2) Labial palps broadly triangular, laterally diverging. Lacinia narrow towards apex. Female gonapophyses reduced to a pair of inconspicuous, acuminate valves, with a basal seta 7
Labial palps short and appressed, somewhat circular. Lacinia not usually narrowed towards apex. Female gonapophyses usually of three valves, the external valve setose; if reduced then not in form of two acuminate valves 8

7 (6) Cu_{1a} fused with M, or joined to it by a crossvein (Stenopsocidae) .... *Stenopsocus striatifrons*
Cu_{1a} not fused nor joined to M (Caeciliidae) .... *Caecilius semifuscatus*

8 (6) Areola postica free or absent. Females sometimes brachypterous or apterous but without glandular setae on head 9
Cu_{1a} fused with M in fully winged forms. Females occasionally brachypterous, but then glandular setae are present 15

9 (8) Tarsi 3-segmented 10
Tarsi 2-segmented 12

10 (9) Fore and hind wings without setae (Mesopsocidae) ..... *Mesopsocus reticulatus*
Fore and hind wings with at least a few marginal setae, even in brachypterous forms; usually with obvious setae 11

11 (10) Hind wing with margin entirely setose. Male hypandrium strongly sclerotized. Female subgenital plate with median lobe (Philotarsidae) 20
Hind wing with at most setae on margin between R_{2+3} and R_{4+5}. Brachyptery common. Male hypandrium lightly sclerotized. Female subgenital plate usually bilobed (Elipsocidae) 24

12 (9) Areola postica absent 17
Areola postica present 13

13 (12) Wings without setae (Lachesillidae) ..... *Lachesilla pedicularia*
Wings setose 14

14 (13) Distal parts of veins in fore wing with more than one row of setae (Pseudocaeciliidae) ..... *Cladioneura punctata*
Distal parts of veins in fore wing with one row of setae (Elipsocidae) 24

15 (8) Tarsi 2-segmented (Psocidae) 27
Tarsi 3-segmented 16

16 (15) Fore wings without setae. Wing pattern of numerous, confluent, irregular dark areas giving wing a densely mottled appearance (Myopsocidae) 47
Wing pattern bold, made up of large hyaline and coloured areas or without pattern (Elipsocidae) 24

17 (12) Hind wing with Rs and M fused for a length. R_1 meets margin at acute angle (Peripsocidae) 44
Hind wing with Rs and M joined by a crossvein. R_1 meets margin at right angle or almost so (Ectopsocidae) 48

18 (4) Fore wing with Rs branched. Hind wing developed ..... *Echmepteryx brunnea*
Fore wing with Rs simple. Hind wing reduced to small, pointed, flap ..... *Echinopsocus grayi*

19 (4) Fore wings reduced but present as broad flaps ..... *Lepinotus reticulatus*
Fore wings virtually absent, represented by a small tubercle ..... *Cerobasis guestfalica*

20 (11) Setae of fore wing veins sited on distinct dark brown spots, at least in basal half of wing; flagellar segments 6-8 with light apices 21
Setae of fore wing veins not sited on dark brown spots. Flagellar segments 6-8 without light apices 22

21 (20) In fore wing Cu_2 bare, setae of apical veins sited on distinct brown spots .... *Aaroniella rawlingsi*
In fore wing Cu_2 setose, setae of apical veins not sited on brown spots .... *Haplophallus medialis*

22 (20) In fore wing Cu_2 setose or wing very reduced. Antennal apex attenuated, with a single, long seta 23
In fore wing Cu_2 bare. Antennal apex not attenuated, not with a single long seta ..... *Haplophallus sinus*

23 (22) Femora and tibiae largely dark chocolate brown; female brachypterous ..... *Haplophallus bundoorensis*
Femora and tibiae light brown; female macropterous or brachypterous *Haplophallus guttatus*

24 (16) Areola postica fused with M or joined to it by a crossvein 25
Areola postica free 26

25 (24) M with more than 3 branches ..... *Pentacladus eucalypti*
M with 3 branches ..... *Propsocus pallipes*

26 (24) Areola postica with Cu_{1a} curved to give a convex distal margin to cell. Hypandrium simple, without postero-lateral lobes .... *Spilopsocus masseyi*
Areola postica with Cu_{1a} sinuous to give a concave distal margin to cell. Hypandrium with rounded postero-lateral lobes ..... *Spilopsocus ruidis*

27 (15) Fore wing veins obviously setose ..... *Lasiopsocus michaelseni*
Fore wing veins without or apparently without setae 28

28 (27) Fore wing with overall speckled pattern ..... *Blaste magnifica*
Fore wing hyaline or patterned, in which case pattern is not speckled 29

29 (28) Cell M_3 narrow. M_3 and Cu_{1a} parallel ..... *Blaste angusta*
Cell M_3 not markedly narrow. M_3 and Cu_{1a} not parallel 30

30 (29) Pterostigma with spurvein 31
Pterostigma without spurvein 33

31 (30) Cells R_3 and R_5 strongly and extensively pigmented ..... *Tanystigma elongata*
Cells R_3 and R_5 not strongly and extensively pigmented 32

32 (31) Distinct pigmented area near margin only in cell R_1 ..... *Tanystigma bifurcata* ♀
No distinct pigmented area near margin in cell R_1 ..... *Tanystigma tardipes*

33 (30) Fore wing hyaline except for pigmented area at margin in cell R_1 or also over whole of cell R_1 basad of hind angle of pterostigma 34
Wing markings otherwise 35

34 (33) Pigmented area near margin and over whole of cell R_1 basad of hind angle of pterostigma ..... *Ptycta hollowayae* ♂
Pigmented area of cell R_1 only near margin ..... *Tanystigma bifurcata* ♂

35 (33) Median cells strongly pigmented ..... *Psocidus mouldsi*
Median cells not strongly pigmented 36

36 (35) Area around nodulus not pigmented 37
Area around nodulus pigmented 38

37 (36) Phallosome open posteriorly ..... *Lasiopsocus dicellus* ♂
Phallosome closed posteriorly ..... *Ptycta hollowayae* ♂

38 (36) Cell R_1 strongly pigmented beyond hind angle of pterostigma ..... *Psocidus parilla*
Cell R_1 not so pigmented 39

39 (38) Cell R_5 with pigment spot anterior to areola postica ..... *Ptycta glossoptera*
Cell R_5 without such a spot 40

40 (39) No spot at separation of M and Cu_1 41
Spot of colour at separation of M and Cu_1 42

41 (40) No dark areas in basal cells .... *Ptycta longipennis*
Some dark areas in basal cells .... *Ptycta umbrata*

42 (40) Spot at separation of M and Cu_1 almost reaching Cu_2 43
Spot at separation of M and Cu_1 small ..... *Blaste macrops*

43 (42) Area around Rs and M junction pigmented ..... *Lasiopsocus dicellus* ♀
Area around Rs and M junction hyaline ..... *Ptycta hollowayae* ♀

44 (17) Fore wings grey with hyaline areas, visible even in brachypterous females ..... *Peripsocus edwardsi*
Fore wing without such markings 45

45 (44) Fore wing with Rs, M basad of fusion with Rs and nodulus narrowly bordered with brown .... *Peripsocus hickmani*
Fore wings without such markings 46

46 (45) Epicranial plates pale, bordered with pale brown ..... *Peripsocus maoricus*
Epicranial plates pale with a few brown marks adjacent to compound eyes, across vertex and adjacent to median epicranial suture ..... *Peripsocus notialis*
Epicranial plates very dark brown, a narrow pale stripe from epistomial suture towards back of head on each epicranial plate ..... *Peripsocus hollowayi*

47 (16) Larger species, fore wing length 5.0-5.5 mm ..... *Phlotodes australis*
Smaller species, fore wing length 3.4-3.6 mm .... *Phlotodes hickmani*

48 (17) Vertex pale brown, postclypeus much darker ..... *Ectopsocus californicus*
Vertex pale with darker spots, postclypeal ground colour not much darker than vertex, postclypeus with dark stripes ..... *Ectopsocus cetratus*

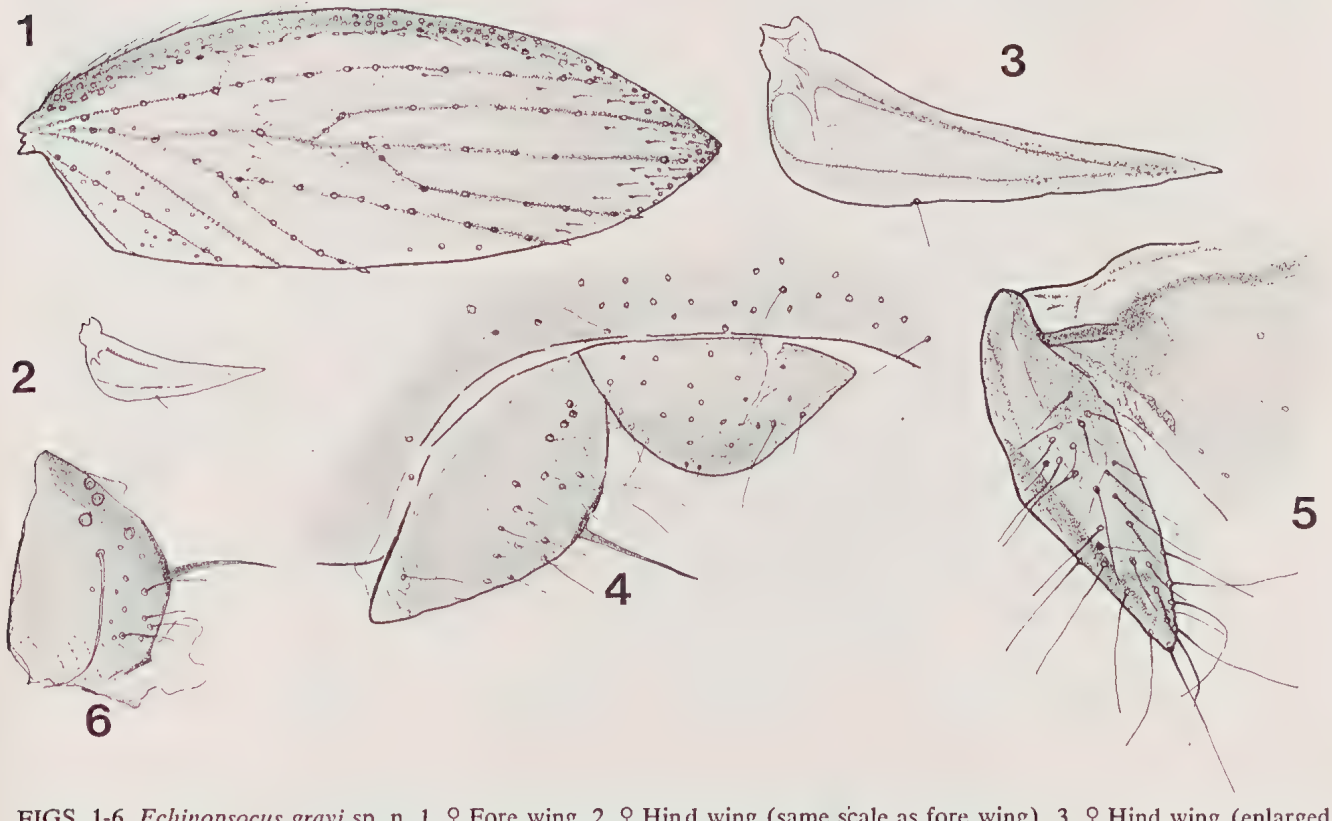
Family LEPIDOPSOCIDAE

Echinopsocus grayi sp. n.

Female

Coloration (in alcohol): Head, body, legs, antennae and maxillary palps golden brown. A faint suggestion of a darker, curved narrow line mesad of each compound eye, a darker median epicranial suture, a median line running length of pronotum and mesoscutum and with margins of mesoscutum dark. Apex of abdomen darker than head and thorax. Ocelli black. Eyes black. Fore wing transparent, tinged with golden brown; veins a little darker than rest of wing surface; when viewed with transmitted light a somewhat mottled appearance is evident with very faint indication of broad, transverse, irregular banding. Hind wing transparent, colourless.

Morphology: Brachypterous. Most of scales lost in available material, those present long and very narrow. Somewhat thickened fore wings not reaching apex of abdomen. Abdominal terga membranous under fore wings (i.e. as far as tergite 7); eighth and ninth tergites and terminal structures well sclerotized. Length of body: 2.5 mm. Median epicranial suture and anterior arms very distinct. Vertex sharp. Head with long, dense pubescence. Postclypeus bulbous. Antennae incomplete in all specimens; scape and pedicel broad, remaining segments short, about twice as long as wide. Eyes fairly large, reaching level of vertex, with an occasional seta between facets. IO/D:2.0; PO:0.7. Ocelli well-developed, anterior ocellus only a little smaller than lateral ocelli. Lacinia narrow, parallel-sided with an emarginate apex so that the end is divided into a smaller inner tooth and a larger outer tooth. Maxillary palp with elongate second segment with small sensillum; fourth segment a little broadened distally. Prothorax sharp dorsally, strongly pubescent. Measurements of hind leg: F: 0.72 mm; T: 1.16 mm; t_1: 0.43 mm; t_2: 0.11 mm; t_3: 0.11 mm; rt: 4:1:1. Hind femur short and broad, dorsal edge convex with large setae. Tibia long and narrow, apex with two stout and one small spur. Claws with preapical tooth but without evident denticles basad of tooth. Fore wing length: 1.96 mm; width: 0.72 mm. Fore wing (Fig. 1) not reaching apex of abdomen, narrowing towards apex; membrane somewhat thickened. Anterior margin somewhat thickened. Distal section of Sc (i.e. from stigmapophysis to marginal thickening) distinct. R_1 runs parallel to wing margin for a long length, reaching margin not far short of wing apex. Rs fused with M for a short length just distad of stigamapophysis, simple, not branched. M 2-branched, the anterior branch, apparently M_1 is, in fact, Rs. Cu_1 forks at level of stigmapophysis so that the areola postica is long. Veins not well developed but evident, indicated by position of rows of long, erect setae, represented by alveolae in figure. Membrane densely



FIGS. 1-6. *Echinopsocus grayi* sp. n. 1. ♀ Fore wing. 2. ♀ Hind wing (same scale as fore wing). 3. ♀ Hind wing (enlarged). 4. ♀ Epiproct and paraproct. 5. Gonapophyses. 6. ♂ Paraproct.

covered with scales and scale-like setae, most of which are lost in available specimens. Hind wing length: 0.44 mm, width: 0.12 mm. Hind wing (Figs. 2, 3) reduced to a membranous, acuminate flap with faint suggestion of one vein near anterior border and another, even less distinct, running more or less parallel with the hind margin. A single small seta occurs about half-way along hind margin. Epiproct (Fig. 4). Paraproct (Fig. 4). Subgenital plate simple, rounded behind. Gonapophyses (Fig. 5). Ninth tergite and median part of eighth tergite more heavily sclerotized than other abdominal terga, being the areas exposed through wing reduction.

Male

Coloration (in alcohol): As female.

Morphology: General morphology as female, similarly brachypterous. Eyes as in female. Length of hind leg: F: 0.64 mm; T: 1.04 mm; t_1: 0.39 mm; t_2: 0.08 mm; t_3: 0.08 mm; rt: 4.9:1:1. Fore wing length: 1.68 mm; width: 0.68 mm. Form and venation as in female. Hind wing as in female. Hypandrium well sclerotized, with gently rounded hind margin, a group of strong setae in middle of hind margin. Phallosome with external parameres posteriorly strongly acuminate, their apices strongly incurved. Epiproct simple, rounded behind. Paraproct (Fig. 6).

Material Examined: SOUTH AUSTRALIA. ♀ (holotype), ♂ (allotype), in litter, Mambray Creek, 19.iv. 1973, M. Gray. Paratypes: 2 ♀, as holotype.

Holotype, allotype and paratypes in the Australian Museum.

Discussion: Echinopsocus Enderlein was erected on the basis of a single specimen, in poor condition, of *E. erinaceus* Enderlein from New Guinea (Enderlein 1903). No additional material of this genus has become available until now. *E. grayi* has most of the generic characters of *E. erinaceus* but differs in the fore wings not having a long apical extension although they are somewhat pointed. Enderlein (1903, p. 331) indicated that he was unable to find ocelli in *E. erinaceus* but they are present in *E. grayi*. The venation of *Echinopsocus* is quite distinctive, however, and *E. grayi* agrees with the type species. R_1 is long; Rs is not branched, appearing to arise from M owing to the evanescence of the basal section of that vein basad of its fusion with M; M is 2-branched, the anterior branch reaching the margin near the bluntly pointed wing apex. Although most of the setae and scales have been lost from the four available specimens, those which remain and the arrangement of alveolae indicate that *E. grayi* is clothed in scales through which protrude a fairly dense covering of strong, erect setae, as described for *E. erinaceus*. The immediately apparent difference between *E. grayi* and *E. erinaceus* is the difference in wing shape, the apical extension being considerable in *E. erinaceus* whereas the apex is bluntly pointed in *E. grayi*.

Although *E. grayi* does not conform to the characters of the generic definition so far as ocelli and fore wing shape are concerned it is not considered necessary to erect a separate genus for it. It suffices to enlarge the limits of *Echinopsocus* to include species which do have ocelli and in which the wing shape is more nearly normal.

Echmepteryx (Loxopholia) brunnea Smithers

Echmepteryx (*Loxopholia*) *brunnea* Smithers 1965. *J. ent. Soc. Qd.* 4: 75, Figs. 11-16.

Material Examined: SOUTH AUSTRALIA. 1 ♀, Yalata, 131°45′E, 31°30′S, 29.ix.1978, M. S. and B. J. Moulds. 1 ♀, 40 km. W. Nullarbor, 130°29′E, 31°28′S, 29.ix.1978, M. S. and B. J. Moulds.

This species has been recorded from New South Wales and Queensland.

Family TROGIIDAE

Cerobasis guestfalica (Kolbe)

Hyperetes guestfalicus Kolbe, 1880. *Jber. westf. ProvVer. Wiss. Kunst* 8: 132; pl. IV, fig. 22.

Hyperetes pinicola Kolbe, 1881. *Ent. Nachr.* 7: 227.

Tichobia alternans Kolbe, 1882. *Ent. Nachr.* 8: 212.

Cerobasis muraria Kolbe, 1882. *Ent. Nachr.* 8: 212.

Hyperetes tessulatus Hagen, 1883. *Stettin. ent. Ztg.* 44: 216.

Albardia alternans (Kolbe). Jacobson and Bianchi, 1904. *Neuropt. Russ. Emp.* p. 496.

Cerobasis guestfalica (Kolbe). Roesler, 1943. *Stettin. ent. Ztg.* 104: 13.

Material Examined: SOUTH AUSTRALIA. 5 ♀, Port Elliot, 13.v.1980, G. and J. Holloway.

C. guestfalica is a cosmopolitan species which is found in domestic habitats as well as in the wild.

Lepinotus reticulatus Enderlein

!*Clothilla inquilina* (Heyden). Hagen, 1882. *Stettin. ent. Ztg.* 43: 526, Pl. II, Fig. 6.

!*Atropos inquilina* (Heyden). Kolbe, 1888. *Jb. Ver. Naturk. Zwickau* 1887: 190, 191.

Lepinotus reticulatus Enderlein, 1905. *Res. Swed. Exp. Egypt* 18: 31, Fig. 9; Pl. 1, Figs 1, 2; Pl. 2, Figs. 12, 19, 23.

Not represented in the present material; this species has been recorded from caves in South Australia (Smithers, 1972).

Family PSYLLIPSOCIDAE

Psyllipsocus ramburii Selys–Longchamps

Psocus pedicularius Rambur, 1842. *Historie naturelle des Insectes*, p. 323.

Psyllipsocus ramburii Selys-Longchamps, 1872. *Ent. mon. Mag.* 9: 145.

Nymphopsocus destructor Enderlein, 1903. *Zool. Anz.* 27: 76.

Ocelloria gravinympha Weber, 1906. *N.Y. Med. J.* 84: 885, Fig. 1.

Nymphopsocus troglodyta Enderlein, 1909. *Arch. Zool. exp. gen.* 5 (1): 536, Pl. 18, Figs 9-11, 13, 14.

Fita vestigator Navas, 1913. *Rev. Acad. Madrid* 12: 333, Fig. 4.

Fabrella convexa Lacroix, 1915. *Bull. Soc. ent. Fr.* 1915: 194.

Not represented in the present material, this species has been recorded from South Australian caves (Smithers, 1972).

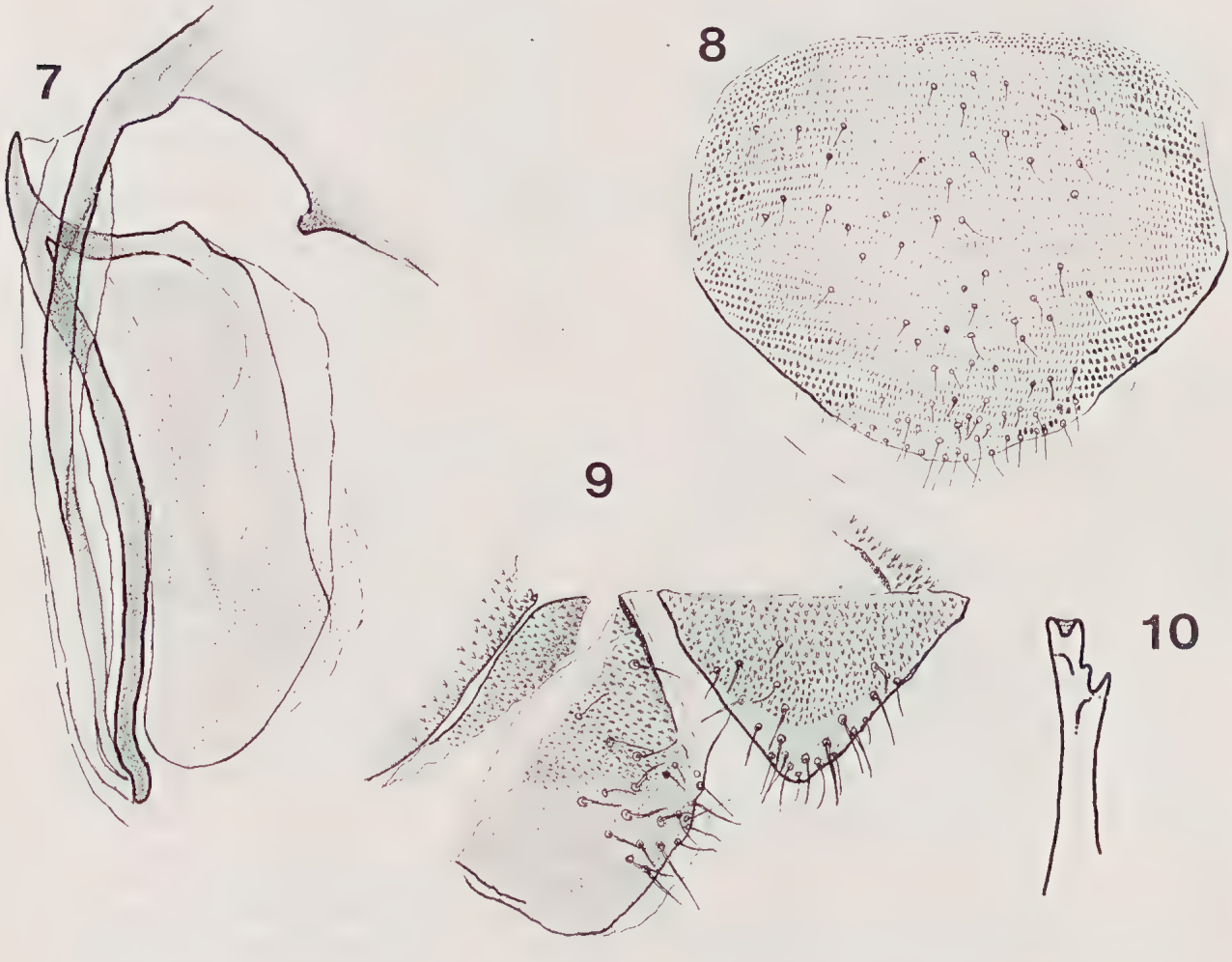
Family PACHYTROCTIDAE

Pachytroctes rugosus sp. n.

Female

Coloration (in alcohol): Head, thoracic nota, legs, first two abdominal terga, a lateral patch on each side of third abdominal tergum and eighth tergum dark brown. Ninth tergum and epiproct pale brown; paraprocts dark brown. Other abdominal terga very lightly sclerotized but segments are indicated by broken bands of subcutaneous brown pigment. Antennae brown, a little paler than head. Eyes black.

Morphology: Apterous. Median epicranial suture extending about one third distance towards epistomial suture; anterior arms represented by a line of tiny papillae visible only in cleared specimen. Hind border of head straight between eyes. Sculpturation of vertex consisting of short, raised bars in haphazard arrangement, that of the postclypeus similar but finer. Lengths of antennal segments: f_1: 0.12 mm; f_2: 0.12 mm. First three flagellar segments without annulations; antennae annulated from fourth



FIGS. 7-10. *Pachytroctes rugosus* sp. n. 7. Gonapophyses. 8. Subgenital plate. 9. ♀ Paraproct. 10. ♀ Lacinia.

segment. Eyes fairly small, their upper margin lying level with vertex. Small tubercles present between facets. Ocelli absent. Lacinia (Fig. 10) apparently with five apical teeth, the fifth not clearly separated. Fourth segment of maxillary palp elongate, four times as long as wide. Thoracic terga of approximately equal width and length, clearly delineated, finely sculptured with small, pointed spicules arranged in irregular transverse rows. Dorsally, the first, second, eighth and ninth terga heavily sclerotized, remaining terga lightly sclerotized, almost membranous, except for a small irregular area near the lateral margin on segment three. Second segment laterally sclerotized. Eighth segment much shorter than ninth, the latter being more than twice as long as eighth and much narrower opposite epiproct than adjacent to eighth tergite. Sculpturation as in thoracic terga but absent from median area in anterior half of second abdominal segment; spicules less densely arranged on ninth tergite, especially in middle of plate. Femora of pro- and mesothoracic legs strongly broadened with long setae. Hind femora only slightly broadened. Measurements of hind leg: F: 0.38 mm; T: 0.49 mm; t_1: 0.24 mm; t_2: 0.05 mm; t_3: 0.07 mm; rt: 4.8:1:1.4. Epiproct (Fig. 9) finely papillate except for a narrow posterior area; setose. Paraproct (Fig. 9), setose, papillae in dorsal half only. Subgenital plate (Fig. 8) very large, setose and papillate, the papillae arranged roughly in transverse rows. Gonapophyses (Fig. 7). *Material Examined:* SOUTH AUSTRALIA. ♀ (holotype), ex dry sclerophyll *Eucalyptus* litter, Melrose, Flinders Ranges, 16.iv.1973. M. R. Gray. Paratypes: 2 ♀, as holotypes. Holotypes and paratypes in the Australian Museum.

Discussion: Pachytroctes rugosus differs from *P. achrosta* Thornton and Woo (from the Galapagos) in lacking postclypeal striations and pale thoracic terga. The gonapophyses are similar in shape but the external valve of *P. rugosus* lacks a sensillum. It differs from *P. tapinelloides* Badonnel (from Africa) in having the fourth and fifth antennal segments annulated. *P. australis* Ribaga, *P. dichrommoscelis* Badonnel and *P. granulosus* Badonnel (all African) differ in having the sculpturation of the vertex in the form of fine granulations, not bar-shaped ridges. In *P. bicoloripes* Badonnel (African), *P. insularis* Thornton and Woo (Marianas) and *P. nivecinctus* Badonnel (African) the metathorax is white. In *P. aglypha* Badonnel (African) the sculpturation of the head is indistinct and, as in *P. aurantiacus* Badonnel (African) and *P. ambiguus* Badonnel (African) there are no granulations between the ommatidia.

The only previous record of this genus from Australia is that of an unidentified species taken from bags of peanuts in shell at Kingaroy, Queensland.

Family SPHAEROPSOCIDAE

Sphaeropsocopsis recens (Hickman)

Sphaeropsocus recens Hickman, 1934. *Occ. Pap. R. Soc. Tasm.* 1933: 83, Figs. 4A-4F.

Sphaeropsocopsis recens (Hickman). Badonnel, 1963. *Biol. l'Amerique australe* 2: 291, 323.

Material Examined: SOUTH AUSTRALIA. 1 ♀, ex *Eucalyptus* litter, dry sclerophyll, Melrose, Flinders Ranges, 16.iv.1973, M. R. Gray. 1 ♀, Mt. Lofty, 26.iv.1943, H. Womersley.

This small interesting species was described from dry grass tussocks in Tasmania (Hickman 1934). The genus is known also from Chile and Angola. The closely related genus *Sphaeropsocus* Hagen is known from one species in Baltic amber.

Family CAECILIIDAE

Caecilius semifuscatus (Tillyard)

Maoripsocus semifuscatus Tillyard, 1923. *Trans. N.Z. Inst.* 54: 191, Fig. 16; Pl. 18, Fig. 11.

Caecilius semifuscatus (Tillyard). Smithers, 1969. *Rec. Canterbury Mus.* 8: 280, Figs. 44-48.

Material Examined: SOUTH AUSTRALIA. 20 ♂, 23 ♀, Wirrulla, ESE Ceduna, 28.ix.1978, M. S. and B. J. Moulds. 1 ♂, 1 ♀, 50 km WNW Ceduna, 28.ix. 1978, M. S. and B. J. Moulds. 12 ♀, Pooginook Park, 13-16.vi.1979, G. A. Holloway. 1 ♀, 20 km SE Pt. Augusta, Horrock's Pass, Flinders Ranges, 17.vi.1979, G. A. Holloway. 2 ♀, 15 km N Port Broughton, 7.v.1980, G. and J. Holloway. 1 ♀, 10 km N Goolwa, 13.v.1980, G. and J. Holloway. 1 ♂, 18 km N Ardrossan, 8.v.1980, G. and J. Holloway. 1 ♂, Telowie Gorge, 10 km E Port Germein, 20.v. 1981, G., J. and A. Holloway.

This species, originally described from New Zealand, has also been recorded from Curtis Island, Bass Strait. These records are the first from the Australian mainland.

Family STENOPSOCIDAE

Steropsocus striatifrons (McLachlan)

Psocus striatifrons McLachlan, 1866. *Trans. ent. Soc. Lond.* (3) 5: 351.

Stenopsocus striatifrons (McLachlan). McLachlan, 1866. *Trans. ent. Soc. Lond.* (3) 5: 352.

This species was described from "Australia meridionali" and is not represented in the present material. The original locality may not have been in South Australia and nothing referable to this species has since been reported in the literature.

Family LACHESILLIDAE

Lachesilla pedicularia (L.)

Hemerobius pedicularius Linnaeus, 1758. *Systema Naturae* p. 551.

Lachesilla pedicularia (L.). Enderlein, 1919. *Cat. Coll. Selys Longchamps* 3 (2): 16.
For complete synonymy see Smithers (1967).

Material Examined: SOUTH AUSTRALIA. 1 ♀, in packing straw from England, Adelaide, v.1937.

L. pedicularia is a very widespread species being known from the Palearctic Region, Comoros, Argentina and South Marianas. There is one previous Australian record, from Victoria.

Family ECTOPSOCIDAE

Ectopsocus californicus (Banks)

Peripsocus californicus Banks, 1903. *J. N.Y. ent. Soc.* 11: 237.

Ectopsocus californicus (Banks) Badonnel, 1955. *Pub. cult. Comp. Diam. Angola* 26: 185.

Ectopsocus congener Tillyard. Smithers, 1969. *Rec. Canterbury Mus.* 8 (4): 289, Figs. 71-75.

Material Examined: SOUTH AUSTRALIA. 1 ♀, 9 km S Edithburgh, 7.v.1980, G. and J. Holloway. 1 ♂, 2 ♀, Mt. Alma, 12 km SW Victor Harbor, 12.v.1980, G. and J. Holloway. 1 ♂, 4 km N Murray Bridge, 22.v.1981, G. and A. Holloway.

This species is known from North America, New Zealand and Antipodes Islands; previous Australian records are from Tasmania and New South Wales.

Ectopsocus cetratus Smithers

Ectopsocus cetratus Smithers, 1972. *Aust. Zool.* 17 (1): 15, Figs. 1-8.

Material Examined: SOUTH AUSTRALIA. 7 ♂, 36 ♀, 3 km E Nundroo, 132°30′E, 31°50′S, 29.ix. 1978, M. S. and B. J. Moulds. 5 ♀, Wilmington, Flinders Ranges, 6.v.1980, G. A. Holloway. 2 ♀, 50 km WNW Ceduna, 28.ix.1978, M. S. and B. J. Moulds. 3 ♂, 10 ♀, 40 km E Nullarbor, 131°15′E, 31°25′S, 29.ix.1978, M. S. and B. J. Moulds. 2 ♀, Yalata, 131°45′E, 31°30′S, 29.ix.1978, M. S. and B. J. Moulds.

This species was described from Western Australia; these are the only subsequent records for the species.

Family PERIPSOCIDAE

Peripsocus edwardsi New

Peripsocus edwardsi New, 1973. *J. Aust. ent. Soc.* 12: 40, Figs. 1-6.

Material Examined: SOUTH AUSTRALIA. 3 ♂, 1 ♀, 20 km. SE Port Augusta, Horrock's Pass, Flinders Ranges, 17.vi.1979, G. A. Holloway. 3 ♂, Germein Gorge, Flinders Ranges, 11.5 km E Pt. Germein, 7.vi.1979, G. A. Holloway. 2 ♂, 2 ♀, Germein Gorge, 19.v.1981, G. and J. Holloway.

This species, in which the females are brachypterous, has previously been recorded only from Victoria.

Peripsocus maoricus (Tillyard)

Peripsocopsis maoricus Tillyard, 1923. *Trans. N.Z. Inst.* 54: 194, Fig. 18; Pl. 18, Fig. 12.

Peripsocus macropterus Edwards, 1950. *Pap. R. Soc. Tasm.* 1949: 124, Figs. 89-94.

Peripsocus maoricus (Tillyard). Thornton and Wong, 1968. *Pacific Ins. Monogr.* 19: 10, 135.

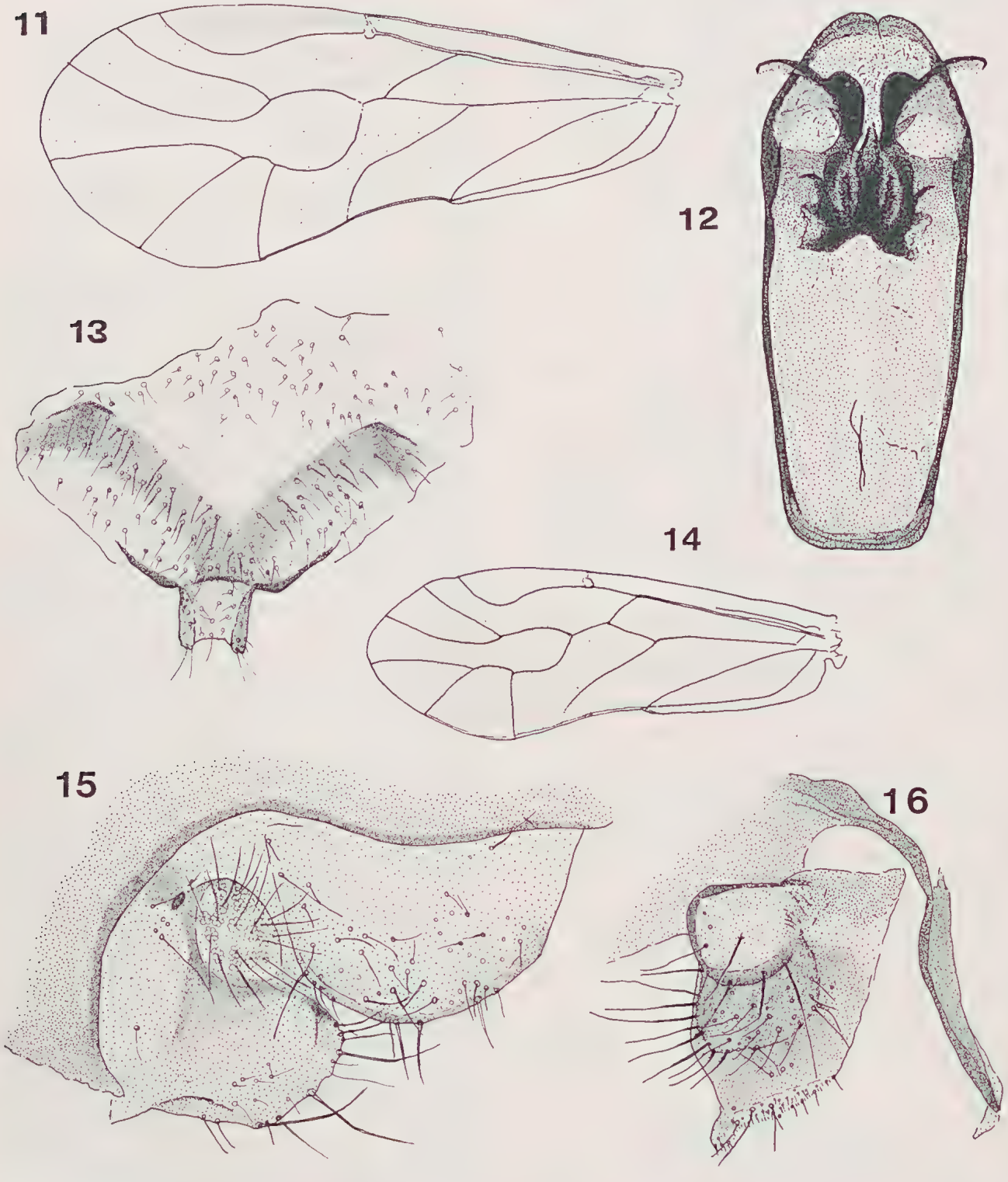
Material Examined: SOUTH AUSTRALIA. 30 ♂, 23 ♀, 6 km W Kapunda, 18.vi.1979, G. A. Holloway. 2 ♂, 6 ♀, 5 n, 9 km S Edithburgh, 7.v.1980, G. and J. Holloway. 7 ♂, 17 ♀, 2 n, Spring Gully Park, 9 km SSW Clare, 18.vi.1979, G. A. Holloway. 1 ♀, Pooginook Park, 15.vi.1979, G. A. Holloway. 3 ♂, Germein Pass, Flinders Ranges, 6.v.1980, G. and J. Holloway. 17 ♂, 17 ♀, Germein Gorge, Flinders Range, 11.5 km E Pt. Germein, 7.vi.1979, G. A. Holloway. 1 ♂, Wirrulla, ESE Ceduna, 28.ix. 1978, M. S. and B. J. Moulds. 21 ♂, 55 ♀, 23 n, 25 km E Peake, 23.vi.1979, G. A. Holloway. 19 ♂, 21 ♀, 1 n, 23 km E Tailem Bend, 13.v.1980, G. and A. Holloway. 12 ♂, 24 ♀, 15 km W Tailem Bend, 13.v.1980, G. and A. Holloway. 9 ♂, 19 ♀, 2 km E Parilla, 23.vi.1979, G. A. Holloway. 11 ♂, 7 ♀, 3 n, 4 km E Pinnaroo, 14.v.1980, G. and J. Holloway. 2 ♂, 2 ♀, 4 km S. Moonta, 7.v.1980, G. and J. Holloway. 2 ♂, 1 ♀, 18 km N Ardrossan, 8.v.1980, G. and J. Holloway. 1 ♂, 6 ♀, 9 n, 10 km N Goolwa, 13.v.1980, G. and J. Holloway. 6 ♀, 20 ♀, 41 n, 16 km S Minlaton, 7.v.1980, G. and J. Holloway. 2 ♂, 13 ♀, Adelaide, 22.ix.1965, H. Womersley. 8 ♂, 10 ♀, 7 n, 12 km SE Port Wakefield, 8.v.1980, G. and J. Holloway, 4 ♂, 2 ♀, 19 n, 2 km W Williamstown, 8.v.1980, G. and J. Holloway. 3 ♂, ex Cypress Pine, Alligator Gorge Rd., near Mt. Remarkable, Flinders Ranges, 17.iv.1979, G. Holloway. 3 ♀, W end of Horrock's Pass, 19.v.1981, G. and J. Holloway. 10 ♂, 17 ♀, ex *Casuarina*, Mt. Gambier, 23.v.1981, G., J. and A. Holloway. 30 ♂, 55 ♀, Germein Gorge, 19-20.v.1981, G. and J. Holloway. 6 ♂, 10 ♀, Burra Gorge, 20 km SSE Burra, 21.v.1981, G., J. and A. Holloway, 1 ♂, 2 km SE Williamstown, 22.v.1981, G. and A. Holloway. 1 ♂, Telowie Gorge, 10 km E Pt. Germein, 20.v.1981, G. and J. Holloway.

Peripsocus maoricus appears to be widely distributed, at least through the southern part of the continent and Tasmania. It has been recorded from Tasmania, Victoria, Western Australia and now from South Australia. It was originally described from New Zealand.

Peripsocus notialis sp. n.

Male

Coloration (in alcohol): Head pale brownish cream with pale brown markings. A few brown marks close against upper margin of compound eyes



FIGS. 11-16. *Peripsocus notialis* sp. n. 11. ♂ Fore wing. 12. Phallosome. 13. Subgenital plate. 14. ♀ Fore wing. 15. ♀ Paraproct. 16. Gonapophyses.

and across vertex with broken patch on either side of median epicranial suture near back of head. Postclypeus with anteriorly converging, pale brown stripes not reaching anteclypeus. Genae and labrum as head. Antennae and maxillary palps brownish. Eyes black. Ocellar tubercle brownish. Lobes of mesothoracic notum pale brown; parapsidal sutures paler than lobes. Legs pale brownish cream with slightly darker tarsi. Fore wing (Fig. 11) hyaline, uniformly very lightly tinged with pale brown; pterostigma opaque but not darker than rest of membrane. Hind wing membrane as fore wing. Veins brown, all well developed, none evanescent. Abdomen pale; phallosome sclerifications indistinctly visible through hypandrium.

Morphology: Median epicranial suture distinct; anterior arms evanescent. Antennae much thicker than in female. Lengths of flagellar segments: f_1: 0.68 mm; f_2: 0.48 mm. Eyes large; reaching well above level of vertex. Facets exceptionally large; eye emarginate where almost in contact with antenna base. IO/D: 0.80; PO: 1.0. Ocelli large, on well developed tubercle. Lacinia very narrow near distal end, hardly divided apically. Fourth segment of maxillary palp long, parallel sided with rounded apex, four times long as wide. Measurements of hind leg: F: 0.60 mm; T: 1.16 mm; t_1: 0.32 mm; t_2: 0.16 mm; rt: 2:1; ct: 22, 0. Legs long and narrow. Fore wing (Fig. 11) with fairly broad costal cell. Cu_1 evanescent just before margin. Fore wing length: 4.0 mm; width: 1.6 mm. Hind wing length: 3.0 mm; width: 1.1 mm. Epiproct triangular with angles rounded, setose, sparsely spiculate in median area near base; spicules very small. No clunial comb. Paraproct simple, ovoid, with very large circular trichobothrial field, the setae long and fine. Hypandrium simple, with a broad sclerotized band parallel with hind margin; margin interrupted in middle; setose. Phallosome (Fig. 12) closed anteriorly with distinctly sclerotized margin interrupted posteriorly. Sclerification of penial bulb heavy, of two, posteriorly outwardly curving sclerites subtended by a complex set of symmetrically arranged sclerites.

Female

Coloration (in alcohol): As male but marks on head a little more extensive. Fore wings (Fig. 14) as in male but costal cell, anterior half of cell R and anterior part of cell R_1 as far as apex of pterostigma hyaline, contrasting with the very pale browish tinge in rest of membrane. Hind wing hyaline, faintly tinged with pale brown along veins. Terminal abdominal structures brown.

Morphology: Length of body: 2.3 mm. Lengths of flagellar segments: f_1: 0.40 mm; f_2: 0.26 mm. Antennae much finer than in males. Eyes fairly small, much smaller than in males. IO/D: 1.7; PO: 0.75. Measurements of hind leg: F: 0.52 mm; T: 0.96 mm; t_1: 0.20 mm; t_2: 0.16 mm; rt: 1.3:1; ct: 8, 0. Fore wing length: 2.8 mm; width: 1.1 mm. Fore wing (Fig. 14). Hind wing length: 2.2 mm; width: 0.8 mm. Epiproct (Fig. 15). Paraproct (Fig. 15) simple, with small trichobothrial field, the setae long and fine. Subgenital plate (Fig. 13). Gonapophyses (Fig. 16).

Material Examined: SOUTH AUSTRALIA. ♂ (holotype), ♀ (allotype), ex cypress pine, Alligator Gorge Rd., near Mt. Remarkable, Flinders Range, 17.vi.1979, G. A. Holloway. Paratypes: 5 ♂, 19 ♀, as holotype (one ♀ on slide). Other material: 5 nymphs, as holotype.

Holotype, allotype and paratypes in the Australian Museum.

Discussion: Peripsocus notialis is a species which is somewhat sexually dimorphic. The female has the anterior part of the wing hyaline in contrast to the uniformly coloured wing of the male. The female wings are considerably shorter than in the large male and the legs are stouter, with fewer ctenidia not regular in arrangement. In general arrangement the sclerifications of the penial bulb resemble these in *P. norfolkensis* Smithers & Thornton and *P. maoricus* (Tillyard) but differ in proportion and shape. The female differs in IO/D ratio and in wing colour. Proportions of the gonapophyses also differ but they resemble each other in having a broad ventral valve. *Peripsocus notialis* is similar in size to *P. edwardsi* New but differs in having much paler wings. In *P. edwardsi* the wing membrane is faintly tinged with grey but there are discrete hyaline patches in most cells. In *P. notialis* the male fore wing membrane is very faintly but uniformly tinged with pale brown. In the female the costal cell and a narrow strip behind R and R_1 is hyaline. The female is somewhat brachypterous. There are slight differences in proportions of the gonapophyses and, although similar in general structure, the male phallosome has differently proportioned sclerifications of the penial bulb. In *P. hamiltonae* Smithers, a slightly smaller species, there is a distinct darkening across the wing from stigmapophysis to nodulus, which is not present in *P. notialis*. *P. hickmani* New is a much smaller species than *P. notialis* with a fore wing length of less than 3 mm as opposed to that of 4 mm for *P. notialis*. In *P. hickmani* there is a little pigmentation adjacent to the basal section of Rs and M basad of fusion with Rs which is absent from *P. notialis*. The phallosome in *P. notialis* has a transverse anterior border with complex sclerification of the penial bulb and narrow, outwardly curved external parameres. In *P. hickmani* the phallosome

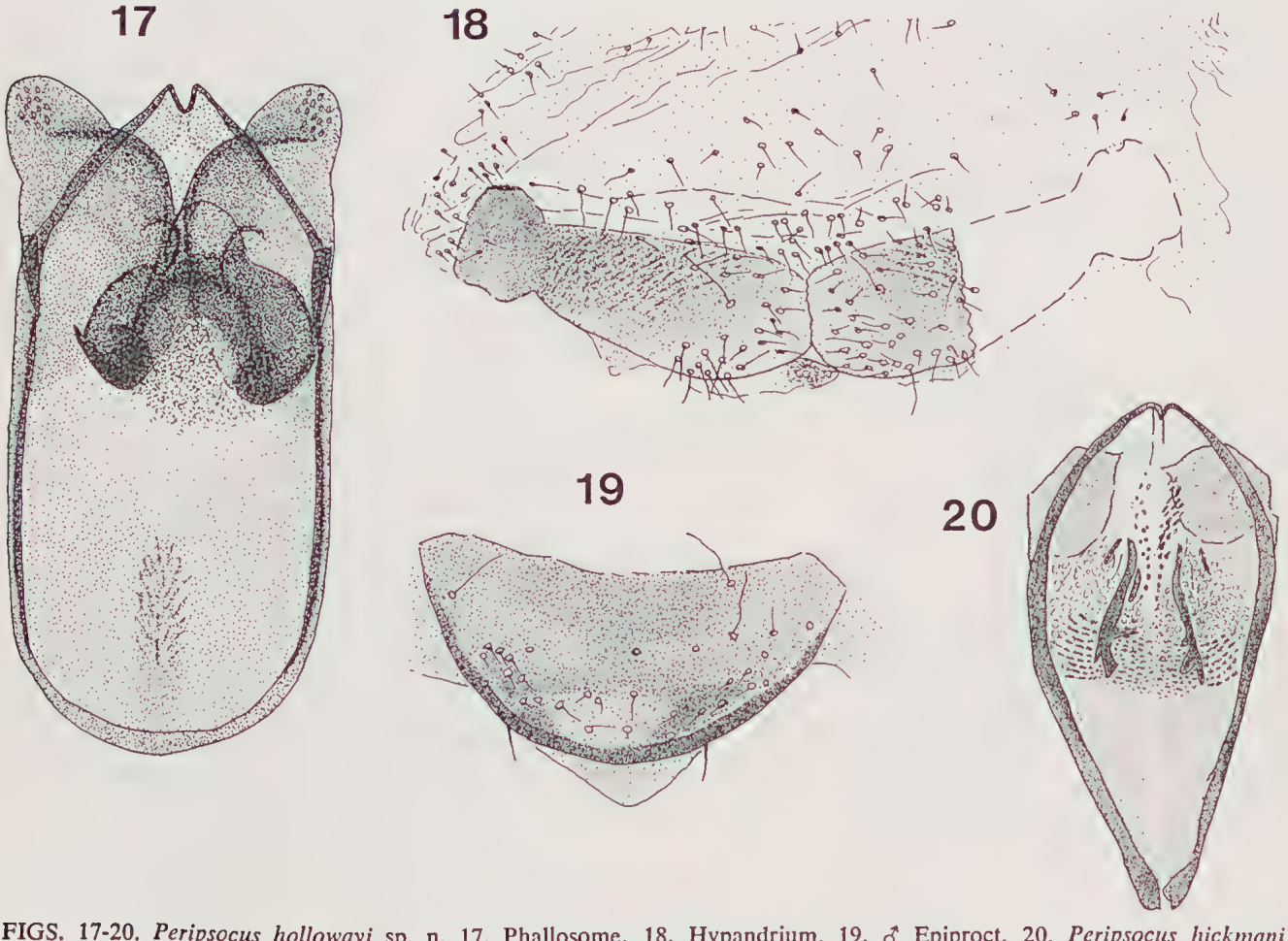
tapers to a broken, narrow anterior end and the external parameres are broad and short; the sclerifications of the penial bulb are simpler, being in the form of a few longitudinal rods and a rugosely sclerotized bulbous area. *P. maoricus* has a distinctive three lobed apex to the arch formed by the distally fused inner parameres and the wing is uniformly more darkly tinted than in *P. notialis*. *P. notialis* is much larger than *P. melaleucae* New. The female of *P. melaleucae* has tapering lateral extensions of the sclerotized area of the subgenital plate; these areas are broad in *P. notialis*. The phallosome of *P. melaleucae* has short, broad, external parameres. In *P. milleri* (Tillyard), *P. morulops* (Tillyard) and *P. tillyardi* New the wings are much darker in general with even darker areas along some of the wing veins. In *P. roseus* Smithers the pterostigma is distinctively reddish in the distal half in life (this color fades in alcohol). The main veins have dark and light sections which give a distinctive appearance of being broken and discontinuous.

Peripsocus hollowayi sp. n.

Male

Coloration (in alcohol): Head very dark brown except for a paler area between ocellar tubercle and antenna base, narrowing laterally to proximity of compound eye and epistomial suture and a similar pale narrow stripe from this area towards back of head on each epicranial plate. Postclypeal stripes hardly discernible (might be more easily seen on paler specimens?). Labrum coloured as head. Antennae dark brown. Maxillary palps dark brown. Eyes black. Ocellar tubercle very dark brown. Mesothoracic notum very dark brown, lacking pale median stripe; lateral lobes each with a narrow paler mark running from scutellum to lateral margin near wing base; a pale spot where parapsidal sutures converge. Coxae dark brown. Legs pale brown. Fore and hind wings hyaline with dark brown veins. Abdomen pale, terminal structures very dark brown, the large, broad phallosome clearly visible through paler integument of abdomen.

Morphology: Median epicranial suture very distinct, as is epistomial suture. Length of flagellar segments: f_1: 0.56 mm; f_2: 0.40 mm. Eyes only moderately large, small for a male. IO/D: 1.7; PO: 0.88. Lateral ocelli large, anterior ocellus much smaller. Measurements of hind leg: F: 0.62 mm; T: 1.28 mm; t_1: 0.28 mm; t_2: 0.14 mm; rt: 2:1; ct: 15, 0. Fore wing length: 3.3 mm; width: 1.2 mm. Hind wing length: 2.5 mm; width: 0.8 mm. Pterostigma fairly shallow, hind angle not pronounced, shallowly rounded. Epiproct (Fig. 19) heavily



FIGS. 17-20. *Peripsocus hollowayi* sp. n. 17. Phallosome. 18. Hypandrium. 19. ♂ Epiproct. 20. *Peripsocus hickmani* Phallosome.

sclerotized, with semicircular hind margin very strongly sclerotized and a small posterior median membranous extension with rounded hind margin. Paraproct well sclerotized with large, circular trichobothrial field. Hypandrium (Fig. 18) (damaged in preparation) with median emargination, lightly sclerotized except for a broad, well-sclerotized medially interrupted band parallel with hind margin. Phallosome (Fig. 17) well sclerotized, broad, rounded anteriorly; external parameres broad; internal parameres distally fused, ending in a pair of blunt processes. Sclerifications of penial bulb heavy, symmetrically arranged.

Material Examined: SOUTH AUSTRALIA. 1 ♂ (holotype), ex cypress pine, Alligator Gorge Rd., near Mt. Remarkable, Flinders Ranges, 17.vi.1979, G. A. Holloway. Paratype: 1 ♂, Germein Gorge, Flinders Ranges, 11.5 km E Pt. Germein, 7.vi.1979, G. A. Holloway.

Holotype and paratype in the Australian Museum.

Discussion: Peripsocus hollowayi is a large species with dark head and thorax and hyaline wings. The broad phallosome, with broad, external parameres and two short posterior processes with heavily sclerotized penial bulb sclerifications is characteristic and distinguishes it from all other species.

Peripsocus hickmani New

Peripsocus hickmani New, 1973: *J. Aust. ent. Soc.* 12: 341, Figs 5, 7-10.

When this species was described from Victoria (New 1973, p. 341, Figs 5, 7-10) male material was not available. The males in the present material permit description of that sex here.

Male

Coloration (in alcohol): As female (New 1973, p. 341).

Morphology: Length of body: 2.2 mm. Median epicranial suture very clearly defined. Lengths of flagellar segments: f_1: 0.40 mm; f_2: 0.30 mm. Antennae shorter than in female. Eyes fairly large, larger than in female but only just reaching level of vertex. IO/D: 1.2; PO: 0.81. Measurements of hind leg: F: 0.44 mm; T: 0.92 mm; t_1: 0.20 mm; t_2: 0.12 mm; rt: 1.7:1; ct: 16, 0. Fore wings as in female (New 1973, Fig. 7). Fore wing length: 2.8 mm; width: 1.1 mm. Hypandrium simply rounded behind, not medially emarginate, a broad, lightly sclerotized band parallel with margin, slightly interrupted in midline. Phallosome (Fig. 20) similar to that of *P. tillyardi* New (1973, Fig. 12) but broader; sclerifications of penial bulb symmetrical.

Material Examined: SOUTH AUSTRALIA. 1 ♂, 1 ♀, Yalata, 131°45′E, 31°30′S, 20.ix.1978, M. S. and B. J. Moulds, 3 ♂, 6 ♀, 18 km N Ardrossan, 8.v.1980, G. and J. Holloway.

Discussion: The male phallosome of *P. hickmani* resembles that of *P. tillyardi* in general form but differs in being wider in relation to length and in having the external parameres almost as wide as long, whereas in *P. tillyardi* they are more elongate, distinctly longer than wide.

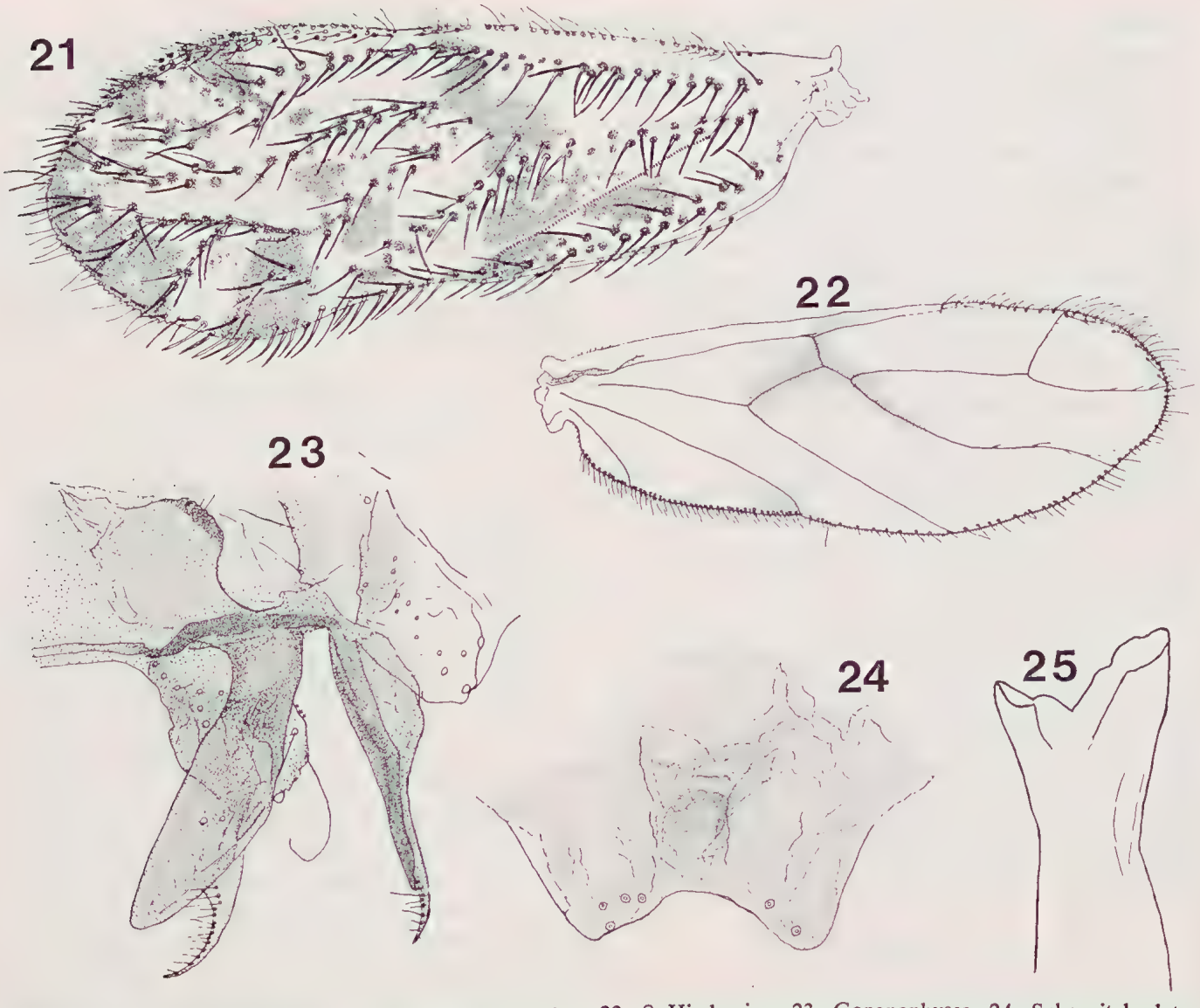
Family PSEUDOCAECILIIDAE

Cladioneura punctata sp. n.

Female

Coloration (in alcohol): Head ivory, with very faint suggestion of median brown band from vertex to labrum and very pale greyish patch mesad of each compound eye. Median epicranial suture not obviously coloured. Antennae pale brown, a small section at the distal end of each flagellar segment paler. Eyes black. Ocellar tubercle very dark brown, conspicuous against otherwise pale head. Labrum brown. Maxillary palps pale, tip of fourth segment very dark brown. Mesonotum with dark brown antedorsum and lateral lobes; parapsidal sutures pale. Metanotum with lateral lobes brown. Pleura mainly brown. Coxae brown basally, pale distally. Femora pale, without dark bands. Tibiae pale. Tarsi brown. Claws black. Fore wings (Fig. 21) hyaline with dark brown markings. Hind wings hyaline with a faint infuscation adjacent to basal section of Rs and M between separation from Cu_1 and fusion with Rs. Abdomen pale with a few spots on each segment; the dorsum of the ninth tergite, in particular, has an irregular row of darker, larger spots which are conspicuous. Epiproct and paraprocts are pale.

Morphology: Length of body: 2.5 mm. Median epicranial suture distinct, anterior arms less conspicuous. Head, except anteclypeus and genae, with strongly developed erect setae, those on postclypeus shorter and finer than most of those on vertex. Lacinia (Fig. 25). Length of flagellar segments: f_1: 0.40 mm; f_2: 0.28 mm. Eyes fairly small, not reaching level of vertex. IO/D: 2.9; PO: 0.7. Ocelli large, anterior ocellus about as large as lateral ocelli. Measurements of hind leg: F: 0.52 mm; T: 0.96 mm; t_1: 0.28 mm; t_2: 0.14 mm; rt: 2:1. Ctenidiobothria absent. Fore wing length: 2.3 mm; width: 0.9 mm. Fore wing (Fig. 21) with veins evanescent in many places; strong setae arise in two rows mostly alongside rather than on veins. Cu_2 without setae. Hind wing length: 1.8 mm; width: 0.7 mm. Veins sparsely setose only in distal part of wing (Fig. 22). Epiproct almost semicircular with small setae on posterior half and a series of strong setae along



FIGS. 21-25. *Cladioneura punctata* sp. n. 21. ♀ Fore wing. 22. ♀ Hind wing. 23. Gonapophyses. 24. Subgenital plate. 25. ♀ Lacinia.

posterior part of margin. Paraproct simply rounded behind, setose in posterior half with strong posterior marginal setae. Trichobothrial field of about 9 trichobothria, poorly defined. Subgenital plate (Fig. 24) posteriorly bilobed, each lobe with a few strong marginal setae, variable in number (holotype with four on right lobe and two on left). Gonapophyses (Fig. 23).

Male

Unknown.

Material Examined: SOUTH AUSTRALIA. ♀ (holotype), 15 km N Ardrossan, 8.v.1980, G. and J. Holloway. Paratypes: 2 ♀, as holotype. 1 ♀, 16 km S Minlaton, 7.v.1980, G. and J. Holloway.

Holotype and paratypes in the Australian Museum.

Discussion: Cladioneura punctata differs from *C. pulchripennis* Enderlein in details of wing pattern, fore wing development and shape of the tip of the lacinia. In *C. punctata* the most conspicuous wing colour difference is the absence of pigment over most of cell M_3 adjacent to the areola postica and the presence of a spot in cell R_5 at the basal quarter. The wings in *C. punctata* are relatively short and broad being only 2.3 mm long for a body size of 2.5 mm, whereas in *C. pulchripennis* the fore wings approach 3.0 mm for the same body size. The lacinia is broader at the apex in *C. punctata.* The gonapophyses are similar but differ a little in proportions. In *C. punctata* the marginal setae of the subgenital plate are in two groups whereas in *C. pulchripennis* the four setae are more evenly spaced across the hind margin. *C. pulchripennis* is the only other species in the genus.

Family ELIPSOCIDAE

Pentacladus eucalypti Enderlein

Pentacladus eucalypti Enderlein, 1906. *Zool. Jb.* 23: 408; Pl. 23, Fig. 7.

Material Examined: SOUTH AUSTRALIA. 2 ♂, Ravine des Casoars, Kangaroo Is., 28.x.1951, G. F. Gross.

This species has been recorded from New South Wales, Tasmania, Victoria and Queensland.

Propsocus pallipes (McLachlan)

Psocus pallipes McLachlan, 1866. *Trans. ent. Soc.* 3 ser. 5: 349.

Propsocus pallipes (McLachlan). McLachlan, 1866. *Trans. ent. Soc.* 3 ser. 5: 352.

Tricladus froggatti Enderlein, 1906. *Zool. Jb.* 23: 410; Pl. 23, Fig. 6.

Tricladellus froggatti (Enderlein). Enderlein, 1909. *Stettin. ent. Ztg.* 70: 273.

Material Examined: SOUTH AUSTRALIA. 1 ♂, 15 km SW Tailem Bend, 13.v.1980. G. and A. Holloway.

Originally described from Adelaide, this species is known from New South Wales, Tasmania, Queensland and Western Australia. It has not yet been recorded from Victoria but it seems likely that it will be found there.

Spilopsocus masseyi New

Spilopsocus masseyi New 1971. *J. Aust. ent. Soc.* 10: 226, Figs. 7-13.

Material Examined: SOUTH AUSTRALIA. 1 ♂, Port Elliot, 13.v.1980, G. and J. Holloway. 1 ♂, Seal Bay, Kangaroo Island, 2-4.xii.1977, D. K. McAlpine and M. A. Schneider. 1 ♀, 40 km W. Nullarbor, 130°29′E, 31°28′S, 29.ix.1978, M. S. and B. J. Moulds.

This species is recorded from Tasmania, New South Wales and Victoria.

Spilopsocus ruidis Smithers

Spilopsocus ruidis Smithers, 1963. *Pacific Ins.* 5 (4): 894, Figs. 19-25.

Material Examined: SOUTH AUSTRALIA. 1 ♂, Yalata, 131°45′E, 31°30′S, 29.ix.1978, M. S. and B. J. Moulds.

Spilopsocus ruidis has previously been recorded only from New South Wales.

Family PHILOTARSIDAE

Austropsocus sinuosus (Banks)

Zelandapsocus sinuosus Banks, 1939. *Bull. Mus. comp. Zool. Harv.* 85: 441, Fig. 12.

Austropsocus sinuosus (Banks). Thornton and New, 1977. *Aust. J. Zool. Suppl. ser.* 54: 28, Figs. 99-104.

This species was originally described from South Australia (Mt. Lofty Range) but is not represented in the present material.

Haplophallus guttatus (Tillyard)

Philotarsus guttatus Tillyard, 1923. *Trans. N.Z. Inst.* 54: 181, Fig. 8.

Philotarsopsis delicatus Tillyard, 1923. *Trans. N.Z. Inst.* 54: 182, Fig. 9.

Philotarsus greyi Edwards, 1950. *Pap. R. Soc. Tasm.* 1949: 116, Figs. 68-75.

Haplophallus greyi (Edwards). Smithers, 1963. *J. ent. Soc. Qd.* 2: 60.

Haplophallus guttatus (Tillyard). Smithers, 1969. *Rec. Canterbury Mus.* 8: 322, Figs. 158-162.

Material Examined: SOUTH AUSTRALIA. 1 ♂, 15 ♀, 40 km E Nullarbor, 131°15′E, 31°25′S, 29.ix.1978, M. S. and B. J. Moulds. 1 ♂, 7 ♀, 3 km E Nundroo, 132°30′E, 31°50′S, 29.ix.1978, M. S. and B. J. Moulds. 1 ♂, 1 ♀, Myponga, H. M. Hale.

Haplophallus guttatus has been recorded from many localities in New South Wales, Victoria, Western Australia and Tasmania. It is also known from Queensland and was originally described from New Zealand.

Haplophallus bundoorensis New

Haplophallus bundoorensis New, 1971. *J. Aust. ent. Soc.* 10 (1): 25, Figs. 1-10.

Haplophallus capitulatus Smithers, 1972. *Aust. Zool.* 17 (1): 19, Figs. 12-17.

Material Examined: SOUTH AUSTRALIA. 9 ♂, 5 ♀, 6 km W Kapunda, 18.vi.1979, J. Holloway. 2 ♂, 50 km WNW Ceduna, 28.iv.1978, M. S. and B. J. Moulds.

H. bundoorensis is known from Victoria, Queensland and South Australia.

Haplophallus medialis Thornton and New

Haplophallus medialis Thornton and New, 1977. *Aust. J. Zool. Suppl. ser.*, 54: 13, Figs. 26-32, 36.

Material Examined: SOUTH AUSTRALIA. 7 specimens ex *Eucalyptus obliqua* dry sclerophyll forest, Naracoorte Cave Reserve, 25.x.1958, G. F. Gross.

This species was previously recorded from New South Wales, A.C.T., Victoria and South Australia.

Haplophallus sinus Thornton and New

Haplophallus sinus Thornton and New, 1977. *Aust. J. Zool. Suppl. ser.* 54: 20, Figs. 60-68.

Material Examined: SOUTH AUSTRALIA. 1 ♂, Mt. Alma, 12 km SW Victor Harbor, 12.v.1980,

G. and J. Holloway. 1 ♂, 10 km N Goolwa, 13.v. 1980, G. and J. Holloway. 3 ♂, 1 ♀, ex *Casuarina*, Mt. Gambier, 23.v.1981, G., J. and A. Holloway. 1 ♂, Yourambulla Caves, 6 km SW Hawker, 18.v. 1981, G. and J. Holloway.

H. sinus is known previously from only one New South Wales locality.

Aaroniella rawlingsi Smithers

Aaroniella rawlingsi Smithers, 1969. *Rec. Canterbury Mus.* 8: 324, Figs. 163-168.

Aaroniella pallida New, 1971. *J. Aust. ent. Soc.* 10 (1): 29, Figs 11-21.

Material Examined: SOUTH AUSTRALIA. 1 ♂, Mt. Gambier. 23.v.1981, G., J. and A. Holloway.

Originally described from New Zealand this species has been recorded from Victoria, New South Wales, Australian Capital Territory and Western Australia.

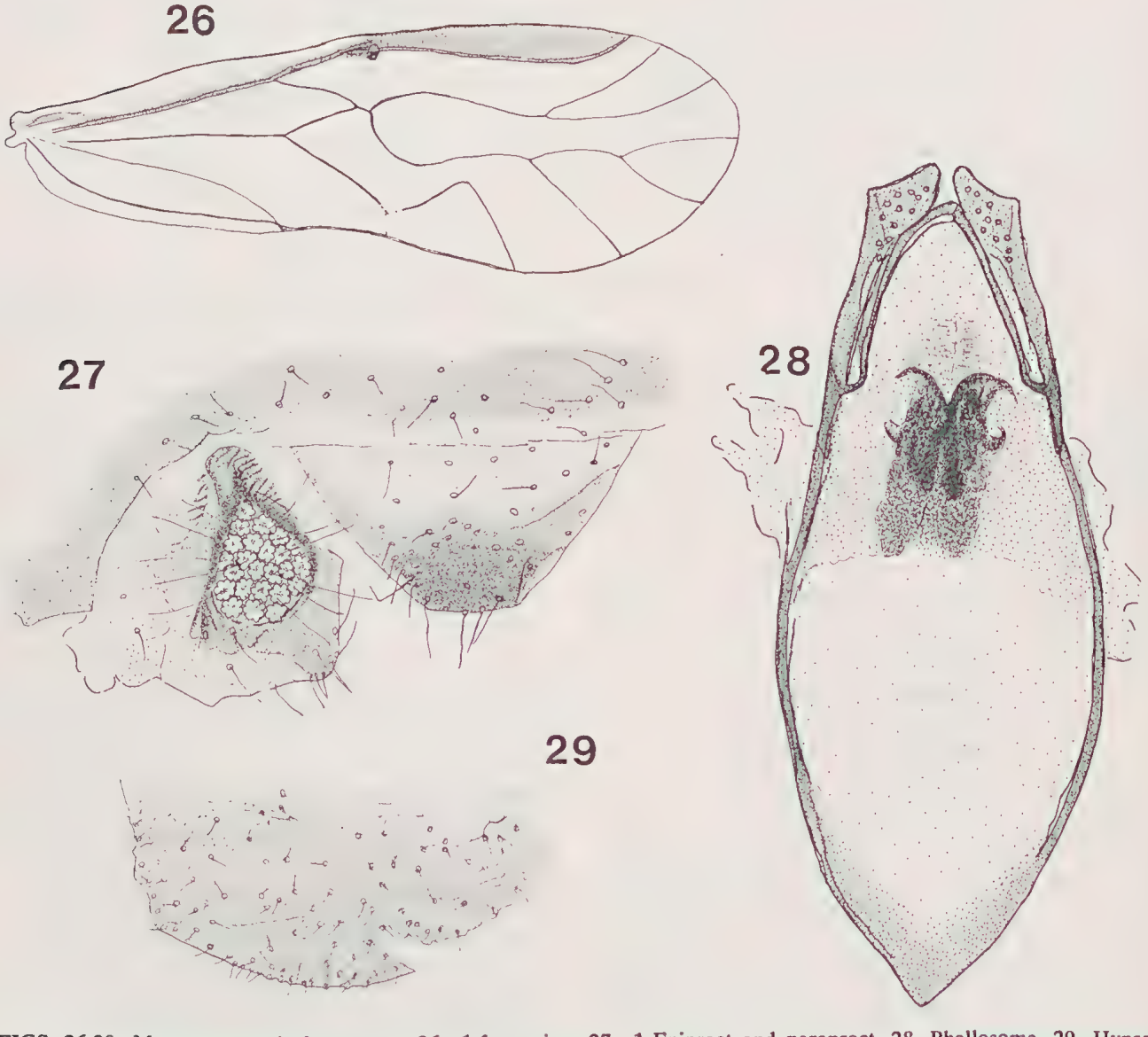
Family MESOPSOCIDAE

Mesopsocus reticulatus sp. n.

Male

Coloration (in alcohol): Head brown, very slightly darker on either side of median epicranial suture and dorsad of compound eyes, lacking the discrete spotting usual in the genus. Median epicranial suture dark brown. Postclypeus brown, anteclypeus pale. Labrum and genae brown. Antennae brown. Eyes black. Ocellar tubercle a little darker than surrounding area. Maxillary palps with all four segments brown. Mesonotum brown, parapsidal sutures pale brown. Pleura brown, a reddish mark laterally on hind part of mesopostnotum. Legs brown. Fore wings (Fig. 26) hyaline, veins and pterostigma brown. Abdomen pale, terminal structures brown.

Morphology: Length of body: 2.2 mm. Median epicranial suture distinct, anterior arms absent.



FIGS. 26-29. *Mesopsocus reticulatus* sp. n. 26. ♂ fore wing. 27. ♂ Epiproct and paraproct. 28. Phallosome. 29. Hypandrium.

Head small, finely pubescent; vertex arched. Sculpturation of head on vertex and frons consisting of a well defined polygonal pattern of raised ridges, that on postclypeus of a series of irregular, fine, transverse ridges. Postclypeus not exceptionally bulbous but reflexed anteriorly so that the anteclypeus is somewhat set back. Posterodistal row of sensilla on anterior margin of labrum made up of three placoid sensilla and two trichoid sensilla almost in a straight line. Anterodistal row of four sensilla. Lengths of flagellar segments (in mm.): f_1: 0.39; f_2: 0.23; f_3: 0.21; f_4: 0.19; f_5: 0.14; f_6: 0.14; f_7: 0.12; f_8: 0.10; f_9: 0.09; f_{10}: 0.08; f_{11}: 0.08. Antennae fairly short, tip mucronate. Total length: 1.81 mm. Eyes fairly large, somewhat protruding but not reaching level of vertex. IO/D: 2.0; PO: 0.86. Ocelli large. Pedicel with two conical sensilla; first flagellar segment with one sensillum with minute point at basal quarter. Fourth and tenth flagellar segments each with a similar sensillum at distal end. Sixth flagellar segment apparently lacks a sensillum. Legs slender. Measurements of hind leg: F: 0.47 mm; T: 1.00 m; t_1: 1.19 mm; t_2: 0.07 mm; t_3: 0.08 mm; rt: 2.7:1:1.1; ct: 10, 0, 0. Fore wing length: 3.5 mm; width: 1.25 mm. Fore wings (Fig. 26) with long, narrow pterostigma, R_1 gently curving. Rs before junction with M slightly curved; fusion with M fairly short. Radial fork about as long as stem. Cu_{1a} slightly curved before rounded apex of areola postica so that basal side of areola postica is slightly concave. Hind wing length: 2.6 mm; width: 0.8 mm. Cu_2 and IA not strongly curved near wing margin. Four minute setae on margin between R_{2+3} and R_{4+5}, readily visible only at magnification greater than about 50×. Epiproct (Fig. 27). Paraproct (Fig. 27). Hypandrium (Fig. 29). Phallosome (Fig. 28) narrowing anteriorly and posteriorly with bluntly pointed anterior end to phallic frame. Penial bulb with strong, symmetrical sclerifications. Aedeagal arch narrow, slightly angled distally. External parameres broad apically, with conspicuous extension but obliquely truncate distally.

Material Examined: SOUTH AUSTRALIA. ♂ (holotype), Germein Gorge, Flinders Range, 11.5 km E Pt. Germein, 17.vi.1979, G. A. Holloway.

Holotype in the Australian Museum.

Discussion: Mesopsocus reticulatus is the first species of the family to be reported from Australia; the genus has previously been recorded from Africa, Europe, Asia and North and South America.

Most species have a distinctive and striking head pattern made up of spots and stripes on the vertex and have the more or less clearly defined postclypeal stripes so characteristic of many psocopterans. *Mesopsocus reticulatus* obviously differs at first sight in lacking this patterning. The head is almost uniformly brown. The antennae are unusually short and the truncate form of the apex of the external parameres and the clearly defined, symmetrical sclerifications of the penial bulb differ in those species in which these structures have been described.

Unfortunately only one specimen, a male, is available; it is possible that the female, as in many other species of *Mesopsocus*, is apterous.

Family PSOCIDAE

Lasiopsocus michaelseni Enderlein

Lasiopsocus michaelseni Enderlein, 1907. *Fauna S.W. Aust.* (1) 3: 234, Figs 1-5.

Blaste (*Lasiopsocus*) *michaelseni* (Enderlein). Roesler, 1943. *Stettin. ent. Ztg.* 104: 3.

Material Examined: SOUTH AUSTRALIA. 2 ♂, 3 nymphs, Pooginook Cons. Park, 15.vi.1979, G. A. Holloway. 1 ♂, 2 km E Parilla, 23.vi.1979, G. A. Holloway. 4 ♂, 5 ♀, 5 nymphs, 4 km E Pinnaroo, 14.v.1980, G. A. and J. Holloway. 2 ♂, 5 ♀, Pandappa Res., 20 km E Terowie, 16.v.1979, G. A. Holloway.

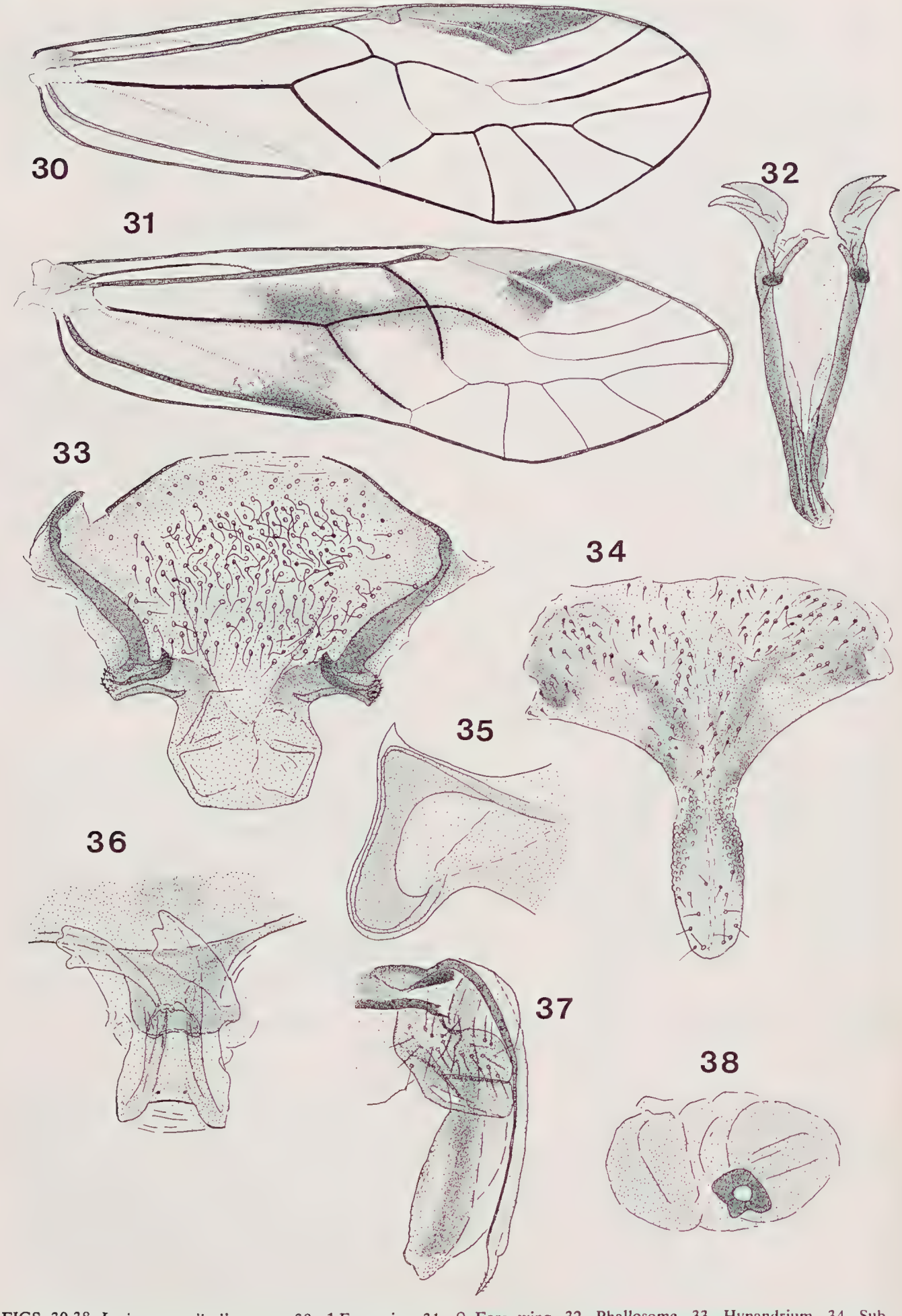
L. michaelseni is one of the largest Australian psocids with a wing length of up to about 7 mm. It was originally described from Western Australia. The record from New South Wales (Muogamarra Nature Reserve) (Smithers 1977) is in error and the specimen referred to there belongs to *L. simulatus* Smithers.

Three of the females from Pandappa Reserve are brachypterous, the wings reaching only to the end of the abdomen. Enderlein (1907) gives wing lengths of 7.0 mm (♂) and 4.7 mm (♀). With the shortening of the wings venational aberration has occurred to the extent that the fusion of Rs and M in the fore wing is shortened so that these veins meet in a point or are even joined by a crossvein. A similar reduction in the length of fusion occurs of Cu_{1a} and M to the point that these veins do not meet at all so the aerola postica is free and the discoidal cell open.

Lasiopsocus dicellus sp. n.

Male

Coloration (in alcohol): Head pale, but brown as follows: a double row of irregular confluent spots adjacent to each compound eye, across back of vertex and on either side of median epicranial suture; a broad spot on frons anterior to ocelli; a line in position of anterior arms of epicranial suture from ocelli to antenna base; a ring around antenna base; a mark below compound eye on gena; postclypeal stripes and the labrum. Median postclypeal stripes closer and darker than lateral stripes. Ocellar tubercle black. Scape and pedicel brown; flagellum very



FIGS. 30-38. *Lasiopsocus dicellus* sp. n. 30. ♂ Fore wing. 31. ♀ Fore wing. 32. Phallosome. 33. Hypandrium. 34. Subgenital plate. 35. Ninth tergite, postero ventral apophysis. 36. ♂ Epiproct. 37. Gonapophyses. 38. ♀ Ninth sternite.

dark brown. Eyes black. First and second maxillary palp segments pale, third brown, fourth dark brown. Dorsum of mesothorax dark, shiny brown, a little paler where parapsidal sutures meet. Fore legs pale brown except for darker apex of tibia and tarsal segments. Meso- and meta-thoracic legs similar but coxae dark brown. Fore wings (Fig. 30) hyaline, without extensive pattern; pterostigma brown; veins dark brown. Hind wings hyaline; veins brown. Abdomen pale, terminal structures very dark brown.

Morphology: Length of body: 4 mm. Median epicranial suture distinct; anterior arms not evident but usual position indicated by brown line. Antennae fine, bearing long setae, those of first flagellar segment up to more than five times longer than width of segment. Eyes fairly large, not reaching level of vertex. IO/D: 1.9; PO: 0.83. Ocelli large. Apex of lacinia divided into two slightly denticulate lobes, the outer strongly divergent; lacinia narrowed just basad of apical division. Measurements of hind leg: F: 1.04 mm; T: 2.04 mm; t_1: 0.60 mm; t_2: 0.20 mm; rt: 3:1; ct: 22, 2. Fore wing length: 5.0 mm; width: 1.6 mm. Pterostigma long, narrow. Stigmapophysis shallow, dome-shaped. M before fusion with Cu_{1a} curved to give a concave outer margin to discoidal cell; curved section of vein somewhat evanescent as are R_{2+3} and R_{4+5} beyond separation. IA fairly thick. An occasional tiny seta present on veins. Hind wing length: 3.7 mm; width: 1.1. Hind wing margin with a few fine, short setae between R_{2+3} and R_{4+5} near wing apex. Epiproct (Fig. 36) sclerotized with a sinuous hind margin. A complex basal structure arises from epiproct where it is attached to ninth tergite. This consists of a posteriorly directed plate which lies above epiproct, the plate is posteriorly bilobed and strengthened along each side by a sclerotized strip, the strips curving away somewhat from each other behind. From the base of the plate arise two erect, elongate, apically 3-lobed strap-like apophyses (twisted in illustration) which are more heavily sclerotized dorsally than ventrally. Paraprocts with very strong, median sclerotized strengthening bar, a large, almost circular trichobothrial field distad of which the paraproct is extended into a medio-dorsally directed tapering bar subtended by a ventrally placed, lightly sclerotized lobe. These lobes are curved inwards and lie behind the distal part of the hypandrium. The eighth sternite sclerotized in distal part only, adjacent to base of hypandrium. Hypandrium (Fig. 36) distally upturned to end in a broad lobe with transverse posterior margin. Ninth tergite extended posteroventrally on each side into a distally broadened lobe with a heavily sclerotized margin. The broadened end is acute dorsally but broadly rounded ventrally (Fig. 35). Phallosome (Fig. 32) with external parameres joined anteriorly, narrow, rodlike, diverging posteriorly, each with a pair of strongly developed, outwardly curved distal teeth. Near the end of each paramere arises a small projection, probably representing the remnants of the internal parameres.

Female

Coloration (in alcohol): As in male but with parapsidal sutures pale, legs darker and with distinct wing pattern in various shades of brown (Fig. 31). This is in strong contrast to the hyaline male fore wing.

Morphology: Length of body: 5.2 mm. Eyes small. IO/D: 2.7; PO: 0.84. Lacinia as in male. Measurements of hind leg: F: 1.2 mm; T: 2.1 mm; t_1: 0.5 mm; t_2: 0.25 mm; rt: 2:1; ct: 21, 2. Fore wing length: 5.0 mm; width: 1.6 mm. R strongly developed. Rs and M fused for a short length. Discoidal cell as in male. Hind wing length: 3.8 mm; width: 1.2 mm. Marginal setae as in male but a little more strongly developed. Paraproct broadbased, narrower posteriorly, well sclerotized with small circular trichobothrial field. Subgenital plate (Fig. 34). Gonapophyses (Fig. 37) with finely pointed ventral valve, dorsal valve blunt-ended, spiculate near end. Sclerification of ninth sternite (Fig. 38) simple, ring-like.

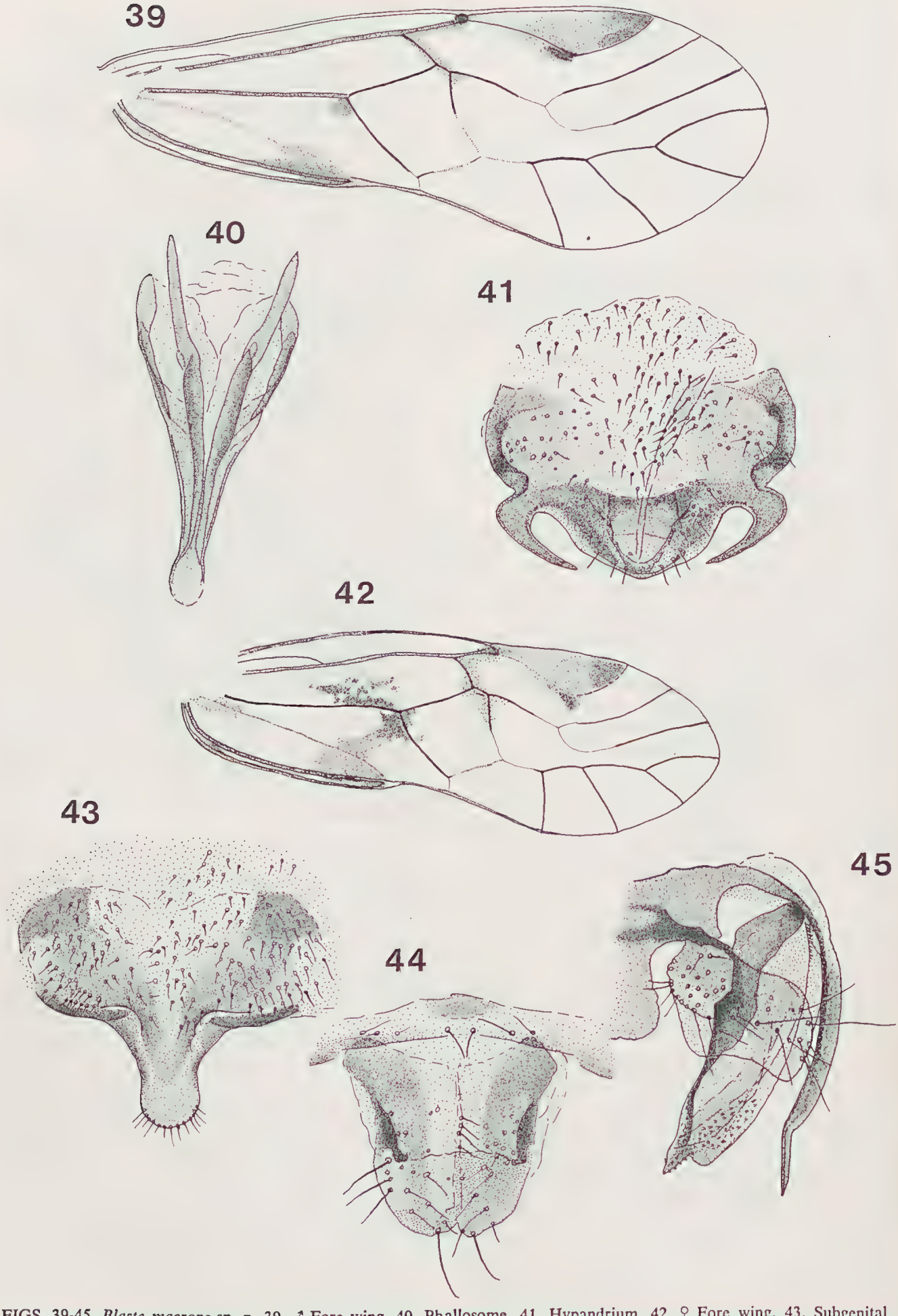
Material Examined: SOUTH AUSTRALIA. 1 ♂ (holotype), 1 ♀ (allotype), Pandappa Res., 20 km. E Terowie, 16.vi.1979. G. A. Holloway. Paratypes: 12 ♂, 6 ♀, data as holotype; 2 ♂, 1 ♀, 4 km NW Murray Bridge, 22.v.1981, G., J. and A. Holloway.

Holotype, allotype and paratypes in the Australian Museum.

Discussion: Lasiopsocus dicellus differs from *L. michaelseni* in being much smaller and darker, with a fore wing length of only 5.0 mm compared with 7.0 mm for *L. michaelseni*. The wing setae are reduced to an occasional small seta, not easily seen. The proportions of the complex structures associated with the male epiproct are different although the distinctive structures are similar in general form and arrangement. The phallosome differs in proportions of the parts. The eighth sternite of the male is sclerotized only in a narrow band adjacent to the base of the hypandrium and the sternite is thus much less heavily and extensively sclerotized than in other genera of the Amphigerontiinae, to which subfamily *Lasiopsocus* belongs.

The female of *L. michaelseni*, as well as being much larger than that of *L. dicellus*, does not have the extensive dark wing markings characteristic of *L. dicellus*.

Males of *L. dicellus* are very similar to those of *L. simulatus* Smithers but differ slightly in propor-



FIGS. 39-45. *Blaste macrops* sp. n. 39. ♂ Fore wing. 40. Phallosome. 41. Hypandrium. 42. ♀ Fore wing. 43. Subgenital plate. 44. ♀ Epiproct. 45. Gonapophyses.

tions of the phallosome and the structures associated with the epiproct. The posterior lobe of the hypandrium has a transverse hind margin in *L. dicellus* but is more rounded in *L. simulatus*. The female of *L. simulatus* is not known.

Blaste macrops sp. n.

Male

Coloration (in alcohol): Head pale with brown markings as follows: a wide band consisting of irregular, sometimes confluent spots adjacent to compound eyes, across vertex and on either side of median epicranial suture (these areas leave only a small part of epicranium clear); a broad band from eye through antenna base and across anterior part of postclypeus to meet band from other side; from the broad band, another runs from between eye and antenna base towards the ocellar triangle. Postclypeus pale with rows of faint spots in positions usually occupied by postclypeal stripes; spots darker in anterior third. Labrum dark brown. Genae pale with dark mark below eye. Antennae brown. Eyes black. Ocelli circled with black. Maxillary palps progressively darker from pale base to dark brown fourth segment. Meso-thoracic antedorsum dark brown except for a small spot on each anterolateral angle and one at junction of parapsidal furrows; dorsal lobes dark brown, broadly pale adjacent to parapsidal furrows and fore wing base; scutellum pale. Metathorax with pale antedorsum and brown dorsal lobes. Femora pale, irregularly marked with pale brown; tibiae pale proximally, becoming dark brown distally; tarsi dark brown. Fore wings (Fig. 39) hyaline, marked in shades of brown. Hind wings hyaline with a pale brown area in distal angle of Cu_2. Abdomen pale, with irregular brown, segmentally arranged markings; terminal structures dark brown.

Morphology: Length of body: 2.8 mm. Median epicranial suture distinct, anterior arms evanescent. Upper region of head somewhat expanded to form lobes on which the eyes are carried so that top of head is broadened; vertex medially depressed. Length of flagellar segments: f_1: 0.85 mm; f_2: 0.90 mm. Antennae slender with fine pubescence. Eyes fairly large, very prominent, carried on upper lateral head extensions, inner margins diverging strongly behind when seen from above. IO/D: 2.1; PO: 0.90. Ocelli large, but ocellar tubercle not very prominent. Measurements of hind leg: F: 0.83 mm; T: 1.9 mm; t_1: 0.6 mm; t_2: 0.15 mm; rt: 4:1; ct: 26, 4. Legs long and slender. Fore wing length: 4.5 mm; width: 1.7 mm. Sc curves distally to meet R. Rs and M fused for a length. Discoidal cell concave, i.e. M curved. M_1 curves, arched towards wing margin, reaching margin just anterior to wing apex. Hind wing length: 3.4 mm; width: 1.1 mm. Microtrichia of wing membrane a little larger in cell Cu_2 than elsewhere. Epiproct rectangular with rounded hind angles. Paraproct heavily sclerotized in basal half, lightly so in distal half; trichobothrial field large and circular, posterior projection small and pointed. Hypandrium (Fig. 41). Phallosome (Fig. 40) with parameres apically separate and tapering, divergent.

Female

Coloration (in alcohol): As male but with a pale median line on mesothoracic antedorsum and more extensive fore wing markings (Fig. 42).

Morphology: Length of body: 3.7 mm. Head much larger than in male, shaped as in male, eyes unusually prominent for a female. Antennae fine. IO/D: 2.5; PO: 0.82. Measurements of hind leg: F: 0.82 mm; T: 1.8 mm; t_1: 0.55 mm; t_2: 0.15 mm; rt: 3.6:1. Fore wing length: 3.7 mm; width: 1.3 mm. Venation as in male but M_1 reaches wing margin at wing apex. Hind wing length: 2.8 mm; width: 0.9 mm. Epiproct (Fig. 44) heavily sclerotized laterally, less so medially with hind margin slightly emarginate medially. Subgenital plate (Fig. 43) well sclerotized. Gonapophyses (Fig. 45).

Material Examined: SOUTH AUSTRALIA. 1 ♂ (holotype), 1 ♀ (allotype), 25 km E Peake, 23.vi. 1979, G. A. Holloway. Paratypes: 3 ♀, 1 ♂, Germein Gorge, Flinders Ra., 11.5 km E Pt. Germein, 17.vi. 1979, G. A. Holloway. 1 ♀, 2 km E Parilla, 23.vi. 1979, G. A. Holloway. 1 ♂, Pandappa Res., 20 km E Terowie, 6.vi.1979, G. A. Holloway.

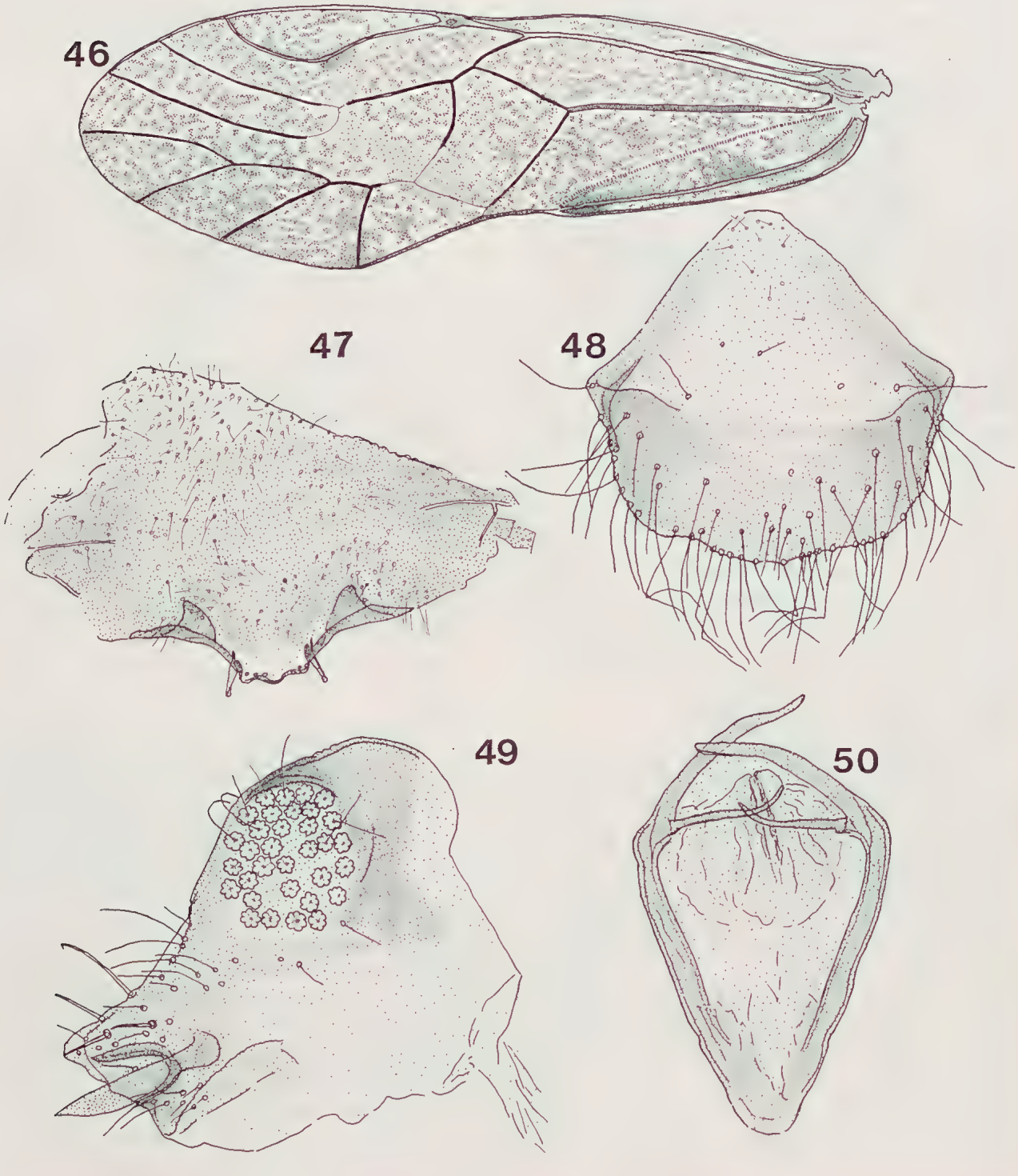
Holotype, allotype and paratypes in the Australian Museum.

Discussion: Blaste macrops belongs to a group of species in which the male hypandrium is rounded, with a pair of lateral, incurved, posteriorly projecting processes and a phallosome in which both inner and outer parameres are elongate, joined anteriorly, with the inner parameres free behind, tapering towards end. The eyes in both sexes are prominently placed on short dorsolateral extensions of the head capsule and there is usually sexual dimorphism in wing pattern with females having somewhat more extensive and often darker markings than males. The group includes *B. falcifer* Smithers (Tasmania), *B. furcilla* New (Western Australia), *B. lunulata* New (Western Australia) and *B. tillyardi* Smithers (New Zealand, New South Wales and South Australia). *B. panops* Smithers (Tasmania) may also be considered as belonging to this group although wing pattern dimorphism is not pronounced and the

male hypandrium lacks the curved processes; the phallosome, however, is very similar to that of *B. falcifer*, as is the shape of the epiproct.

Only the most obvious differences between the species are given here. Perusal of the descriptions and illustrations will provide an indication of the characteristic differences in proportions and shapes of genitalic structures as well as wing pattern differences by which the species can be distinguished.

Both *B. falcifer* and *B. panops* have a distinct mark between the ends of R_{4+5} and M, i.e. near the wing apex which is lacking in *B. macrops*. In *B. lunulata* males (females not known) there are extensive wing markings in cell Cu_2; the band of colour across the wing from pterostigma to areola postica is broad and continuous; M, Rs + M and the edges of the discoidal cell are bordered with brown and the median cells and cell R_5 each apically have



FIGS. 46-50. *Blaste magnifica* sp. n. 46. ♂ Fore wing. 47. Hypandrium. 48. ♂ Epiproct. 49. ♂ Paraproct. 50. Phallosome.

extensive brown markings. These markings are far more extensive than in *B. macrops* (Fig. 39). In *B. tillyardi*, probably the nearest known relative to *B. macrops*, the hypandrial processes are shorter and stouter and the inner parameres posteriorly incurved. In female *B. macrops* there are irregular marks in cell R adjacent to M which are absent from female *B. tillyardi* and *B. furcilla*. Males of *B. furcilla* differ from males of *B. macrops* in having a triangular flap arising from the base of the epiproct (New 1974, Fig. 17).

The generic limits of *Blaste* and its nearest relatives are in need of revision on a world basis and when this is done it seems likely that *B. macrops* and similar species will be defined as a distinct generic group.

Blaste magnifica sp. n.

Male

Coloration (in alcohol): Head brown with dark brown markings. A double row of irregular, confluent spots adjacent to compound eyes, across back of vertex and adjacent to median epicranial suture. Frons with triangular patch with pale centre anterior to ocellar tubercle. Epistomial suture very dark brown. Areas of top of head not occupied by the spotting described above are mostly occupied by brown which does not quite reach the spots. A very dark band runs from compound eye to antenna base. Genae with an irregular mark below compound eye and two small marks above base of mandible. Postclypeal stripes dark and clearly defined. Anteclypeus dark in basal half, pale in distal half. Labrum pale brown with dark brown proximal border. Scape, pedicel pale brown and basal half of first flagellar segment pale brown, remainder of flagellum brown. Eyes black. Ocellar tubercle black. Maxillary palp with third and fourth segments dark brown, otherwise pale. Thorax distinctively marked, being very dark chocolate brown with only parapsidal furrows and a narrow median line between dorsal lobes pale, the line between the dorsal lobes extending for a short distance onto hind part of antedorsum. Pleura mostly dark brown. Femora irregularly marked in various shades of brown, darkest at distal end. Tibiae brown, darker at each end. Tarsi brown. Fore wings (Fig. 46) hyaline, densely speckled brown. Hind wings hyaline, faintly tinged with grey. Abdomen pale with a few brown marks; terminal structures dark brown.

Morphology: Length of body: 3.8 mm. Upper angles of head produced a little so that the eyes are very prominently held on short, thick "stalks". Median epicranial suture very distinct, anterior arms absent. Vertex slightly lower in middle than laterally, thus accentuating eye prominence. Postclypeus almost square when viewed from front of head; not very prominent. Lengths of flagellar segments: f_1: 1.16 mm; f_2: 1.04 mm. Antennae very fine, with long setae, some as long as seven times flagellar diameter. Eyes large, prominent on cephalic extensions, upper margins high above level of vertex. IO/D: 1.4; PO: 0.94. Ocelli large on prominent tubercle; epicranial plates concave on either side of ocellar tubercle, thus accentuating tubercle prominence. Measurements of hind leg: F: 1.12 mm; T: 2.64 mm; t_1: 0.68 mm; t_2: 0.14 mm; rt: 5:1; ct: 29, 2. Legs long, thin, with very spiny tibiae. Femora narrow, parallel sided. Fore wing length: 6.5 mm; width: 2.1 mm. Sc meets R distally. Rs and M fused for a length. Discoidal cell incurved on distal margin. Cu_{1a} and M fused for a length; basal and second sections of Cu_{1a} at a slight angle to one another. Hind wing length: 4.8 mm; width: 1.6 mm. Rs and M fused for a short length. Margin glabrous. Epiproct (Fig. 48). Paraproct (Fig. 49). Hypandrium (Fig. 47). Phallosome (Fig. 50).

Female

Unknown.

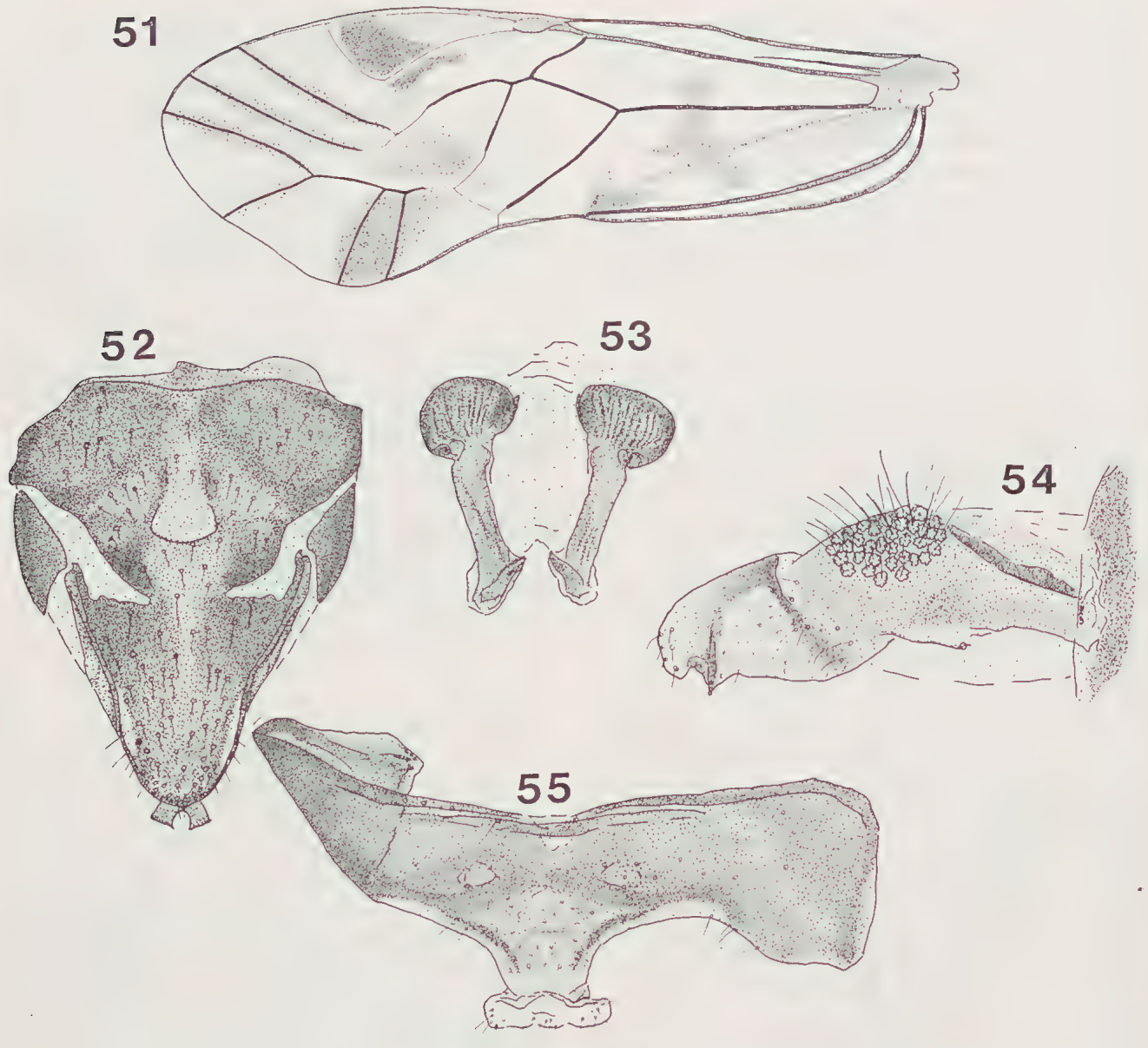
Material Examined: SOUTH AUSTRALIA. ♂ (holotype), Pooginook Park, 15.vi.1979, G. A. Holloway. Paratype: ♂, as holotype.

Holotype and paratype in the Australian Museum. *Blaste magnifica* is a very distinctive, large and easily recognized species. It is the only species in the genus in which the wing is mottled with an overall pattern of small, irregularly confluent spots. The hypandrium is distinctive, with an unusual hind border which is medially sclerotized and carries two small projections, one on each side of the midline. The phallosome is also of unusual form for the genus. As in the case of the group of species associated with *B. macrops*, mentioned above, it may be necessary to recognize this species in a separate genus when the large genus *Blaste* is revised.

Blaste angusta sp. n.

Male

Coloration (in alcohol): Head pale brownish with dark brown, irregular, confluent spots adjacent to compound eyes, across vertex and adjacent to median epicranial suture. A narrow brown band surrounds antenna base. Postclypeal striations dark brown. A brown ovoid patch with pale centre lies anterior to ocellar triangle just posterior to epistomial suture. Genae pale with two small spots below eye. Antennae brown, a little paler in basal four segments than more distally. Maxillary palps pale basally, fourth segment very dark brown. Mesothoracic antedorsum dark brown; parapsidal furrows broadly pale; scutellum pale; a posterior lateral pale line on each dorsal lobe. Femora pale brown, dark



FIGS. 51-55. *Blaste angusta* sp. n. 51. ♂ Fore wing. 52. Hypandrium. 53. Phallosome. 54. ♂ Paraproct. 55. Epiproct and ninth tergite.

along dorsal and lateral surfaces. Tibiae pale brown, a little darker at each end. Tarsi dark brown. Fore wing (Fig. 51) hyaline with markings in various shades of brown. Hind wings hyaline, a brown spot at wing base. Abdomen pale with slightly darker, irregular, segmentally arranged markings in basal two thirds; distal third occupied by the almost black, extensively sclerotized terminal structures; eighth sternite extensively and very heavily sclerotized.

Morphology: Length of body: 3.0 mm. Median epicranial suture very distinct but anterior arms absent. Median part of epistomial suture sinuous. Length of flagellar segments: f_1: 0.80 mm; f_2: 0.64 mm. Flagellar setae about three times as long as flagellar width. Eyes large, inner margins divergent behind when seen from above and just reaching level of vertex. IO/D: 1.9; PO: 1.0. Measurements of hind leg: F: 0.80 mm; T: 1.80 mm; t_1: 0.56 mm; t_2: 0.20 mm; rt: 2.8:1; ct: 27, 1. Fore wing length: 4.0 mm; width: 1.4 mm. Fore wing (Fig. 51) with broad pterostigma, with round hind angle and R_1 curved to give a concave pterostigma basad of hind angle. Rs and M fused for a very short length. Sc ends free in costal cell, runs very close to R. Third median cell very narrow, M_3 and distal sections of Cu_{1a} almost parallel but relationship varies somewhat in the four fore wings available for study. Apex of areola postica fairly broad. Hind wing length: 3.0 mm; width: 1.1 mm. Rs and M fused for a fairly long length. Ninth tergite (Fig. 55) very heavily sclerotized, extended posteriorly in the middle to which extension is attached the small lobed epiproct. Paraproct (Fig. 54). Eighth sternite very heavily sclerotized. Hypandrium (Fig. 52). Phallosome (Fig. 53).

Female

Unknown.

Material Examined: South Australia ♂ (holotype), 10 km SW Renmark, 15.vi.1979, G. A. Holloway. Paratypes: 1 ♂, as holotype. 1 ♂, Telowie Gorge, 10 km SE Pt. Germein, 20.v.1981, G. and J. Holloway. 1 ♂, W end of Horrock's Pass, 19.v.1981, G. and J. Holloway.

Holotype and paratypes in the Australian Museum.

Discussion: Blaste angusta is an easily recognized species. It is so far the only known Australian species of *Blaste* in which cell M_3 in the fore wing is narrow as well as being well pigmented. The parameres, distally broadened into a rough knob, are characteristic.

Ptycta umbrata New

Ptycta umbrata New, 1974. *J. Aust. ent. Soc.* 13: 297, Figs. 38-44.

Material Examined: SOUTH AUSTRALIA. 2 ♂, 1 ♀, 2 km W Williamstown, 8.v.1980, G. and J. Holloway. 3 ♂, 11 n., Wilmington, Flinders Range, 6.v.1980, G. and J. Holloway. 1 ♀, Alligator Gorge Rd., near Mt. Remarkable, Flinders Range, 17.vi. 1979, G. Holloway. 1 ♀, 6 km W Kapunda, 18.vi. 1979, G. Holloway. 1 ♀, 25 km E Peake, 23.vi.1979, G. Holloway. 3 ♂, 1 ♀, Telowie Gorge, 10 km SE Pt. Germein, 20.v.1981, G., J. and A. Holloway. 3 ♀, Germein Gorge, 19.v.1981, G. and J. Holloway.

This species has previously been recorded only from Victoria.

Ptycta glossoptera New

Ptycta glossoptera New, 1974. *J. Aust. ent. Soc.* 13: 302, Figs. 58-64.

Material Examined: SOUTH AUSTRALIA. 6 ♂, 24 n, Pandappa Res., 20 km E Terowie, 16.vi. 1979, G. A. Holloway. 1 ♀ (macropterous), 2 ♀ (brachypterous), 1 n, 2 km E Parilla, 23.vi.1979, G. A. Holloway. 1 ♀ (brachypterous), 1 n, 10 km SW Renmark, 15.vi.1979, G. A. Holloway. 1 ♂, Pooginook Park, 15.vi.1979, G. A. Holloway.

This species has previously been recorded from Victoria.

Ptycta longipennis sp. n.

Male

Coloration (in alcohol): Head greyish with brown markings. A double row of spots adjacent to compound eyes, across back of head and adjacent to median epicranial suture, a mark along anterior arms of suture which broadens toward lateral ends; an ovoid spot anterior to ocellar tubercle. Base of antenna surrounded by a narrow brown band. Postclypeal stripes narrow. Antenna dark brown. Maxillary palps pale, fourth segment very dark brown, almost black. Mesonotum dark brown, sutures, median antedorsal stripe and posterolateral edges of lateral lobes pale. Legs pale, tarsi brown. Fore wing (Fig. 56) hyaline, with a faint general tinge of brown and slightly darker brown areas as in figure. Abdomen pale, irregularly marked with brown; terminal structures dark brown.

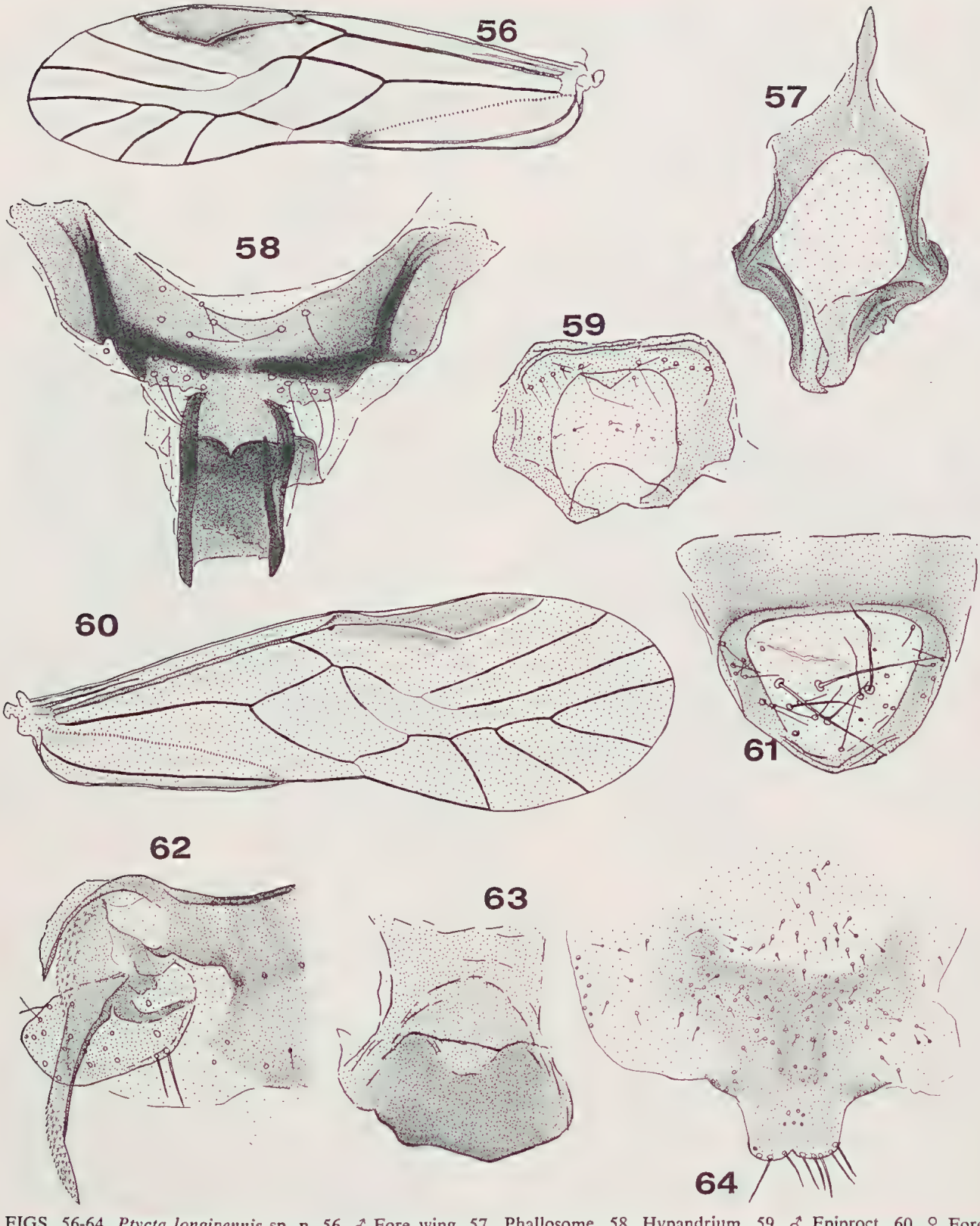
Morphology: Length of body: 2.3 mm. Median epicranial suture distinct; anterior arms evanescent but position marked by dark stripe. Lengths of flagellar segments: f_1: 0.76 mm; f_2: 0.74 mm. Eyes large, reaching above level of vertex. IO/D: 1.3; PO: 0.91. Measurements of hind leg: F: 0.68 mm; T: 1.60 mm; t_1: 0.50 mm; t_2: 0.12 mm; rt: 4.2:1; ct: 30, 3. Fore wing length: 4.0 mm; width: 1.3 mm. Fore wings relatively long and narrow. Sc ending free in costal cell. Pterostigma fairly narrow but hind angle clearly evident. Rs and M fused for a short length. Discoidal cell broad, distal section of M and Cu_1 bordering cell both curved distally towards wing apex. Basal section of Cu_{1a} slightly sinuous almost in a line with second section. Hind wing length: 3.2 mm; width: 0.9 mm. Rs and M fused for a long length. A few marginal setae between R_{2+3} and R_{4+5}. Epiproct (Fig. 59) lightly sclerotized, bordered with slightly more heavily sclerotized band of variable width. The posterior median part is folded back in figure. Hypandrium (Fig. 58) slightly asymmetrical with a lateral, sclerotized extension of the dorsally curved, median, straplike band near the distal end. Phallosome (Fig. 57) with a long posterior median extension.

Female

Coloration (in alcohol): As in male. Wings (Fig. 60) slightly darker.

Morphology: Length of body: 2.6 mm. Lengths of flagellar segments: f_1: 0.60 mm; f_2: 0.60 mm. Eyes smaller than in male, not quite reaching level of vertex. IO/D: 1.7; PO: 0.82. Measurements of hind leg: F: 0.56 mm; T: 1.36 mm; t_1: 0.40 mm; t_2: 0.13 mm; rt: 3:1; ct: 25, 1. Fore wing length: 3.6 mm; width: 1.0 mm. Venation (Fig. 60) as in male. Hind wing length: 2.7 mm; width: 0.8 mm. Epiproct (Fig. 61). Subgenital plate (Fig. 64). Gonapophyses (Fig. 62) with short ventral valve; dorsal valve tapering to point, distally slightly curved upwards; spiculate in distal third. Sclerite of ninth sternite (Fig. 63) simple, lightly sclerotized.

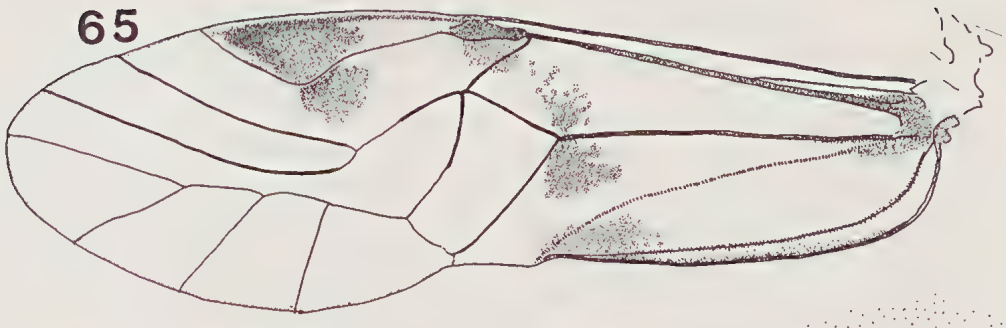
Material Examined: SOUTH AUSTRALIA. ♂ (holotype), ♀ (allotype), Germein Gorge, 19.v. 1981, G. and J. Holloway. Paratypes: 1 ♂, 1 ♀, Telowie Gorge, 10 km SE Pt. Germein, 20.v.1981, G. and J. Holloway. Holotype, allotype and paratype in the Australian Museum.

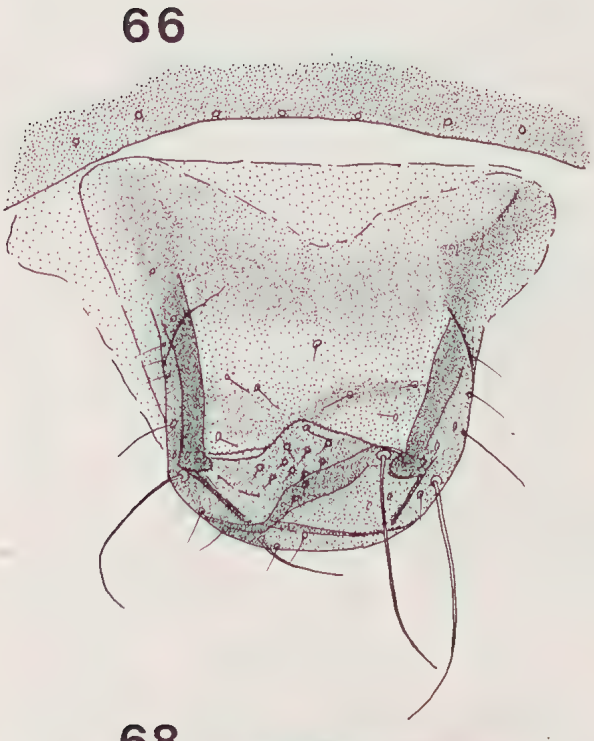


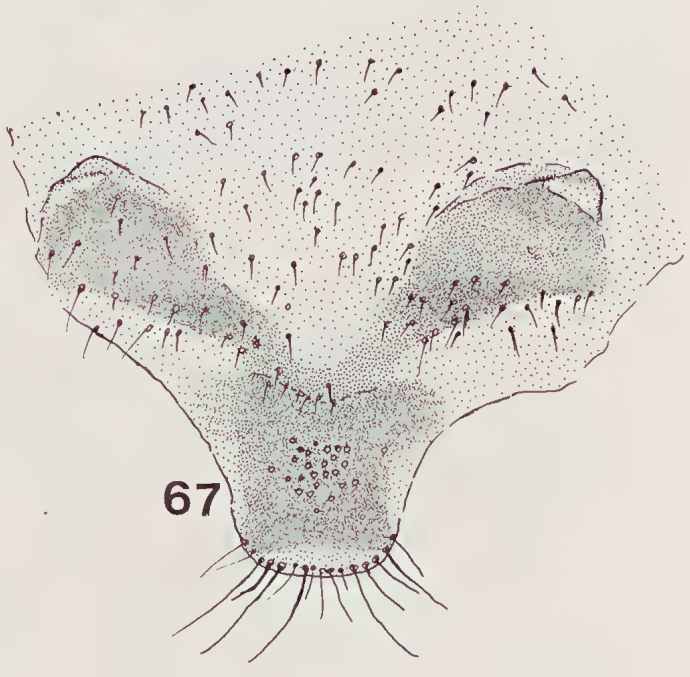
FIGS. 56-64. *Ptycta longipennis* sp. n. 56. ♂ Fore wing. 57. Phallosome. 58. Hypandrium. 59. ♂ Epiproct. 60. ♀ Fore wing. 61. ♀ Epiproct. 62. Gonapophyses. 63. ♀ Ninth sternite. 64. Subgenital plate.

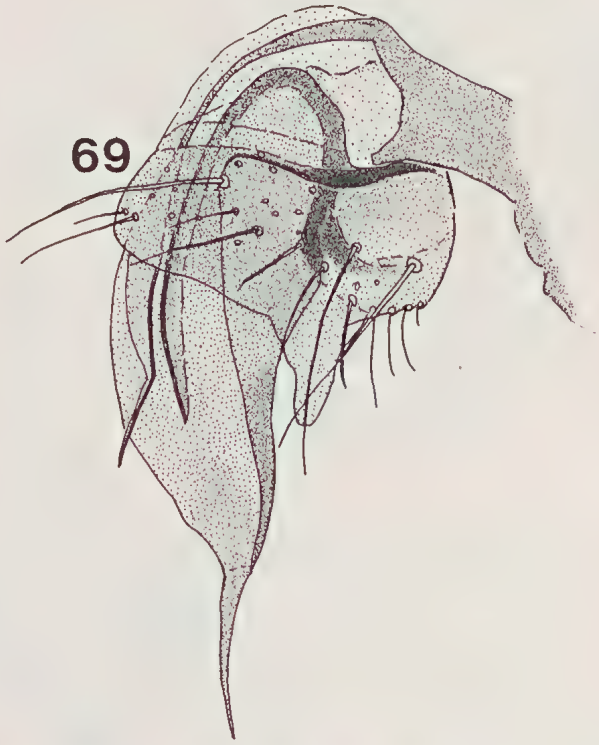
Discussion: Ptycta longipennis is very similar to *P. muogamarra* Smithers, from New South Wales. It is, however, larger and there are distinct differences in several anatomical features. In the male the distal median extension of the phallosome is longer and the median strap-like upcurved part of the hypandrium is more nearly symmetrical. In the female the external valve of *P. longipennis* is broader and, although reduced in a similar way, the ventral valve is more robust. In *P. glossoptera* the hypandrium is strongly asymmetrical and in the other Australian species the hypandrium bears a variety of spines and projections.

Females of *P. emarginata* New, *P. glossoptera* New, *P. improcera* New, *P. picta* New and *P. umbrata* all have some darker brownish marks on the fore









FIGS. 65-69. *Ptycta hollowayae* sp. n. 65. ♀ Fore wing. 66. ♀ Epiproct. 67. Subgenital plate. 68. ♀ Ninth sternite. 69. Gonapophyses.

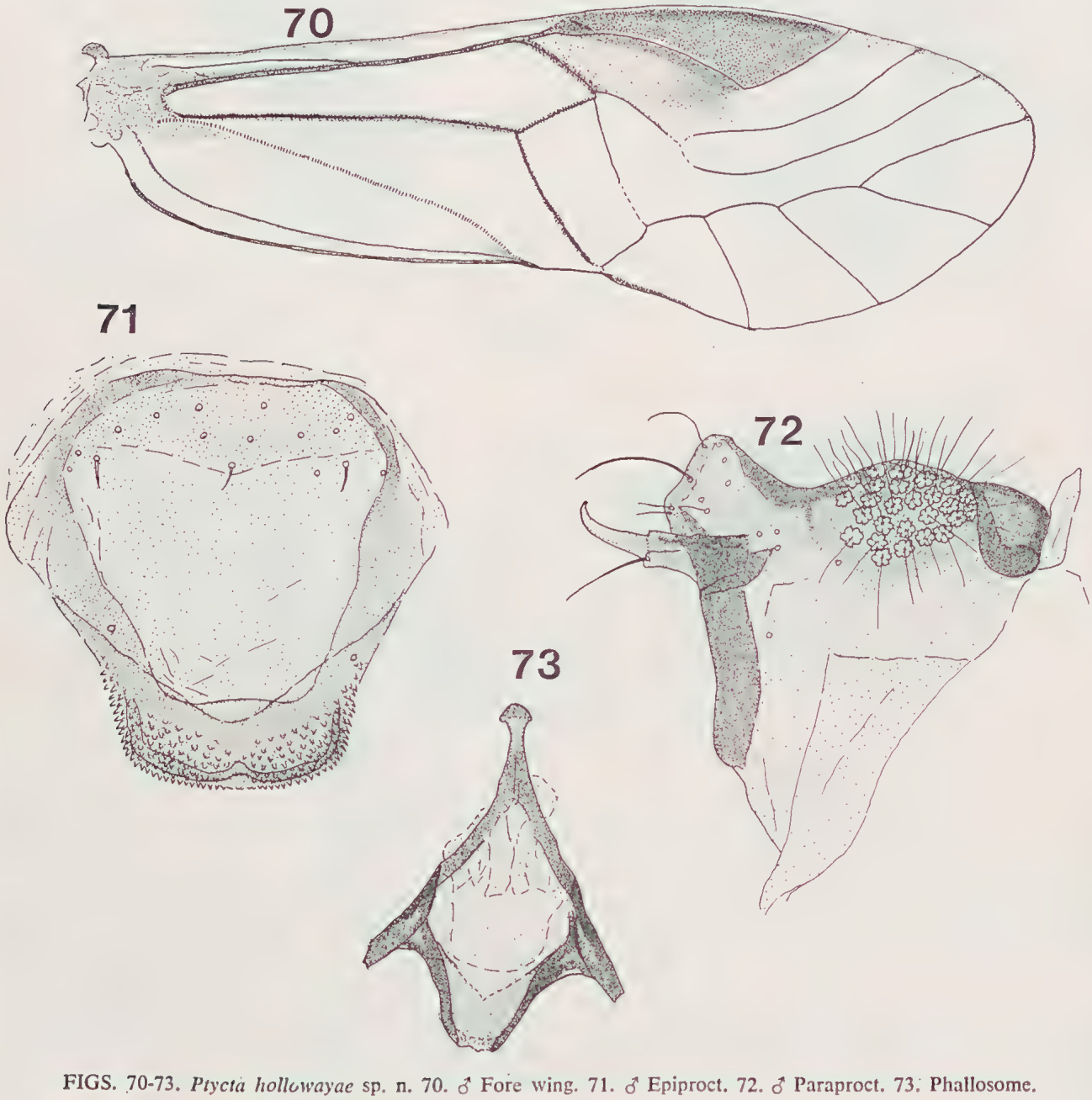
wings. The female of *P. cornigera* is not known but the male does not have obvious dark marks. *P. longipennis* differs from *P. hollowayae* sp. n. (described below) in lacking the rugose areas along the distal border of the epiproct and in not having an apical thickening to the posterior median process of the phallosome; phallosome shape also differs in that the phallic frame is much narrower in *P. hollowayae* and has an anteriorly projecting apophysis on each side at the posterior third of the frame. The fore wing of the female of *P. hollowayae* has an interrupted, irregular brown band from stigmapophysis to nodulus. In *P. hollowayae* the dorsal valve of the gonapophyses is broad and the ventral valve not shortened to the extent that it is in *P. longipennis*.

Ptycta hollowayae sp. n.

Female

Coloration (in alcohol): Head and appendages very similar to *Ptycta emarginata* New but with postclypeal striae not obsolete in midline and frons with a small dark circle in midline anterior to ocelli. Thoracic lobes dark brown but each broadly bordered with pale areas. Fore wings (Fig. 65) hyaline with very faint overall brown tinge and marked in shades of brown. Hind wings hyaline with very faint suggestion of brownish area behind end of Cu_2.

Morphology: Length of body: 3.8 mm. Median epicranial suture distinct, anterior arms absent. Head broad across vertex, eyes large, just reaching level



FIGS. 70-73. *Ptycta hollowayae* sp. n. 70. ♂ Fore wing. 71. ♂ Epiproct. 72. ♂ Paraproct. 73. Phallosome.

of vertex. IO/D: 1.8; PO: 1.0. Ocelli large, anterior ocellus only little smaller than lateral ocelli. Length of flagellar segments: f_1: 0.96 mm; f_2: 0.76 mm. Measurements of hind leg: F: 0.92 mm; T: 2.0 mm; t_1: 0.56 mm; t_2: 0.20 mm; rt: 2.8:1; ct: 22, 4. Front femora noticeably broader than femora of middle and hind legs. Fore wing length: 4.4 mm; width: 1.4 mm. Fore wing with Rs and M meeting in a point, joined by a crossvein or fused for a very short length. Pterostigmal spurvein minute, hardly discernible. Fore wing glabrous. Hind wing length: 3.3 mm; width: 1.1 mm. About ten marginal setae between R_{2+3} and R_{4+5}. Epiproct (Fig. 66). Gonapophyses (Fig. 69). Dorsal valve broad with fairly long apical, pointed extension. External valve with distinct lobe lying adjacent to dorsal margin of dorsal valve. Subgenital plate (Fig. 67) with short, truncate, posterior lobe on the upper side of which near the posterior margin is a small, irregularly shaped thickening of the internal membrane. Y-shaped pigmented area with short, broad, "stem", the ends of the "arms" broad but somewhat apically divided. Sclerification of ninth sternite (Fig. 68) in form of an ovoid, very heavily sclerotized plate.

Male

Coloration (in alcohol): Head and appendages as in female but head markings reduced in accordance with greater eye size. Fore wings (Fig. 70). Hind wings hyaline.

Morphology: Length of flagellar segments: f_1: 1.04 mm; f_2: 0.84 mm. Antennae thicker than in female, finely pubescent. IO/D: 1.1; PO: 1.0. Eyes much larger than in female, reaching well above level of vertex with inner margins diverging posteriorly when viewed from above; emarginate posteriorly-medially above. Measurements of hind leg: F: 1.0 mm; T: 2.24 mm; t_1: 0.60 mm; t^2: 0.18 mm; rt: 3.3:1; ct: 27, 4. Fore wing length: 5.0 mm; width: 1.7 mm. Pterostigmal spurvein absent. Rs and M joined by a very short crossvein, in length only a little greater than vein thickness. Hind wing length: 3.7 mm; width: 1.3 mm. A few fine setae on margin between R_{2+3} and R_{4+5}. Epiproct (Fig. 71) lightly sclerotized with broad, thickened, marginal band of varying width; hind margin transverse; a basal, upstanding, broad-margined lobe partly overlies ninth tergite, the lobe medially slightly emarginate. Paraproct (Fig. 72). Hypandrium similar to that of *Ptycta glossoptera* (New 1974, Fig. 62). Phallosome (Fig. 73).

Material Examined: SOUTH AUSTRALIA. ♀ (holotype), ♂ (allotype), 15 km W Tailem Bend, 13.v.1980, G. and J. Holloway. Paratypes: 1 ♀, as holotype. 1 ♀, 18 km N Ardrossan, 8.v.1980, G. and J. Holloway. 1 ♀, 1 km E Edithburgh, 7.v.1980, G. and J. Holloway.

Holotype, allotype and paratypes in the Australian Museum.

Discussion: Ptycta hollowayae resembles *P. emarginata* New (♀ only known) and *P. glossoptera* New (both sexes known). It differs from both in being larger and the female has more extensive wing markings. The male of *P. hollowayae* differs from that of *P. glossoptera* in the form of the paraprocts and in proportions of the phallosome (although general shape is similar). The lateral projections are more pronounced in *P. hollowayae*. The epiproct and the hypandrium are similar in the two species. The anterior lobe of the epiproct appears to be folded back in the illustration given by New (1974, Fig. 64). In *P. cornigera*, *P. improcera* and *P. umbrata* the hyandrium bears spines and various processes which are not present in *P. hollowayae*. From *P. muogamarra P. hollowayae* differs in the form of proportions of the phallosome and in not having the ventral valve of the gonapophyses reduced. Comparison with *P. longipennis* has been made above.

Tanystigma tardipes (Edwards)

Clematostigma tardipes Edwards, 1950. *Pap. R. Soc. Tasm.* 1949: 95, Figs. 1-17.

Copostigma (*Clematostigma*) *tardipes* (Edwards). Smithers, 1967. *Aust. Zool.* 14 (1): 103.

Tanystigma tardipes (Edwards). Smithers, in press: *Aust. ent. Mag.*

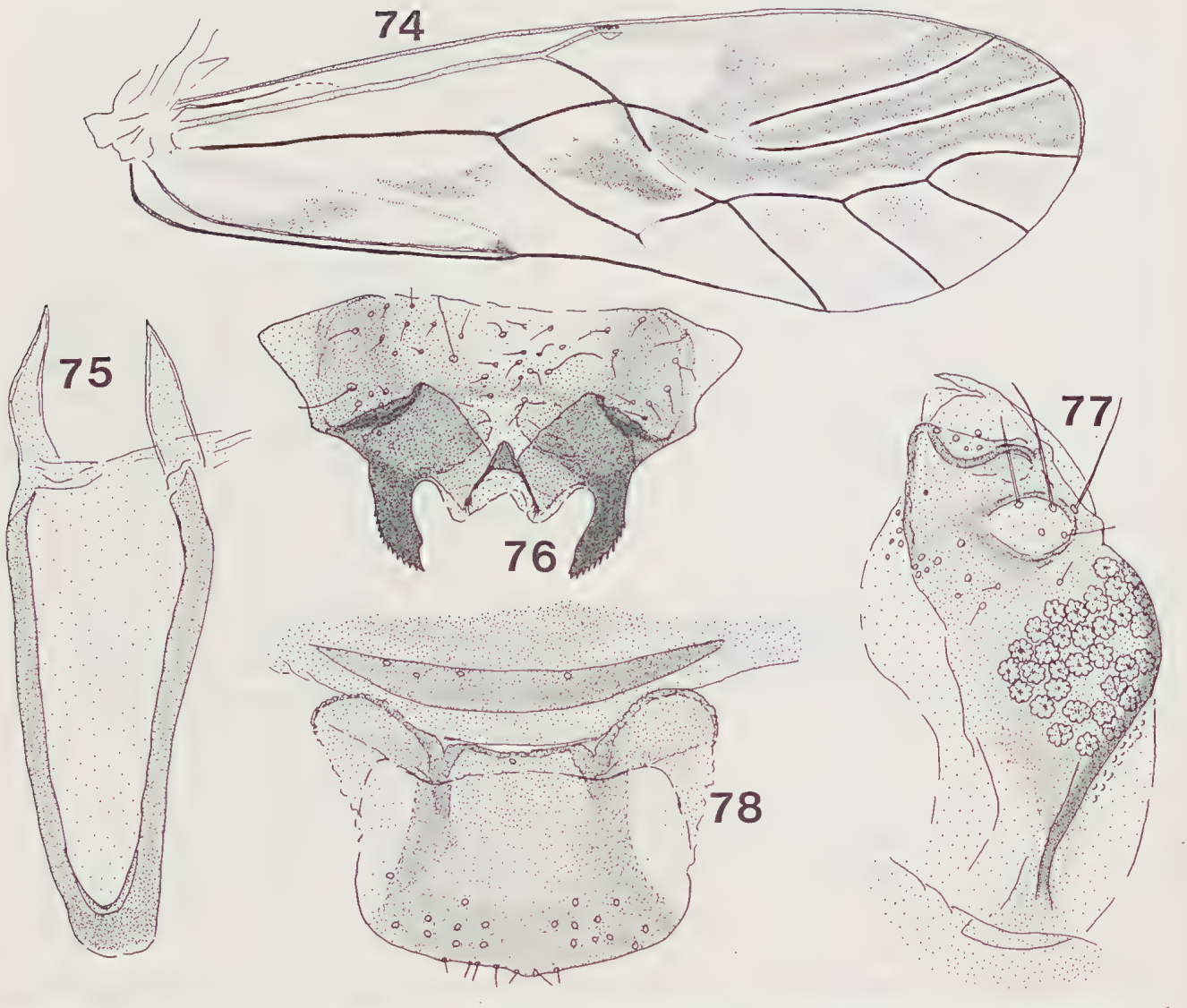
Material Examined: SOUTH AUSTRALIA. 1 ♂, 1 ♀, 12 km SE Port Wakefield, 8.v.1980, G. and J. Holloway. 1 ♂, 3 ♀, 1 n, 4 km S Moonta, 7.v.1980, G. and J. Holloway. 1 ♂, Port Elliot, 13.v.1980, G. and J. Holloway. 2 ♀, Wilmington, Flinders Ranges, 6.v.1980, G. and J. Holloway. 1 ♂, 2 ♀, 18 km N Ardrossan, 8.v.1980, G. and J. Holloway. 2 ♂, 2 ♀, 23 km E Tailem Bend, 13.v.1980, G. and J. Holloway. 1 ♂, 1 ♀, Telowie Gorge, 10 km E Pt. Germein, 20.v.1981, G. and J. Holloway. 4 ♂, 5 ♀, Farina, 17.v.1981, G. and J. Holloway.

T. tardipes was described from Tasmania and has been recorded from Victoria.

Tanystigma elongata sp. n.

Male

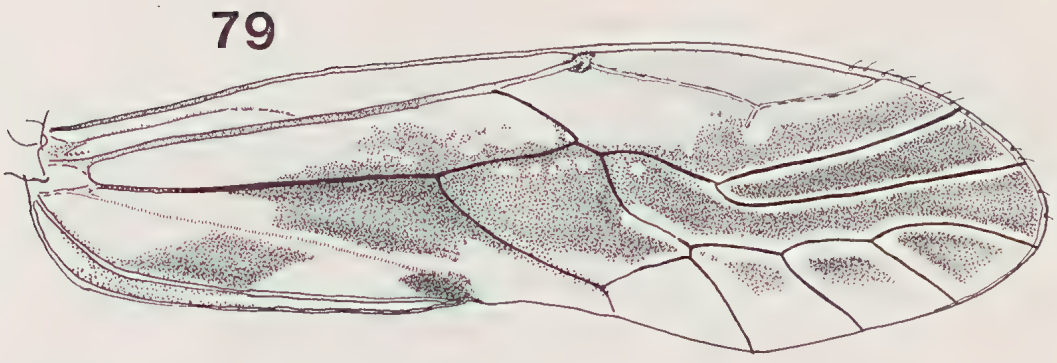
Coloration (in alcohol): Head pale grey-brown with dark brown markings: A double row of confluent spots adjacent to median epicranial suture, across back of vertex and adjacent to compound eyes; a spot between ocellar tubercle and epistomial suture; an irregular ring around antenna base; distinct postclypeal striations. Epicranial suture dark brown. Labrum pale brown. Genae grey-brown. Antennae dark brown. Eyes purplish. Ocellar

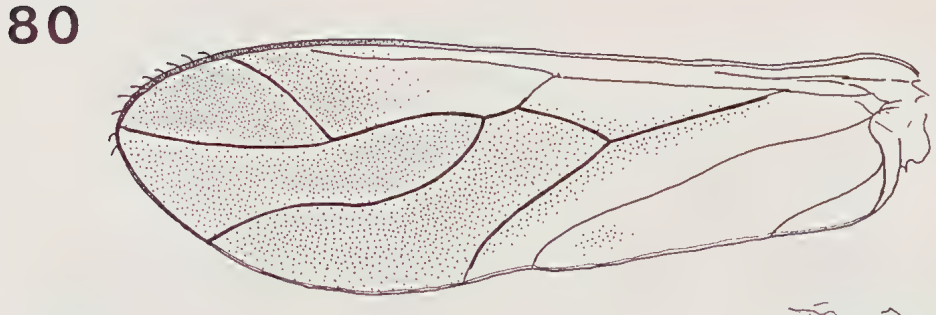


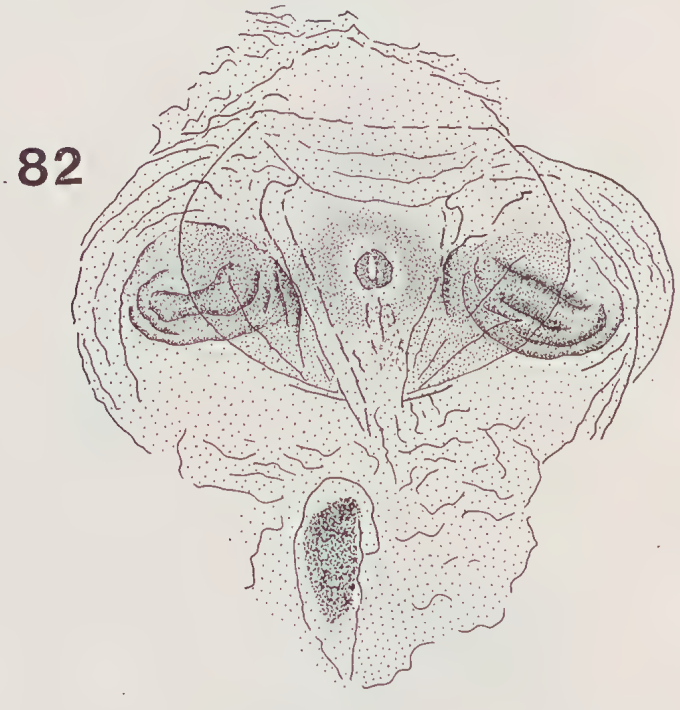
FIGS. 74-78. *Tanystigma elongata* sp. n. 74. ♂ Fore wing. 75. Phallosome. 76. Hypandrium. 77. ♂ Paraproct. 78. ♂ Epiproct.

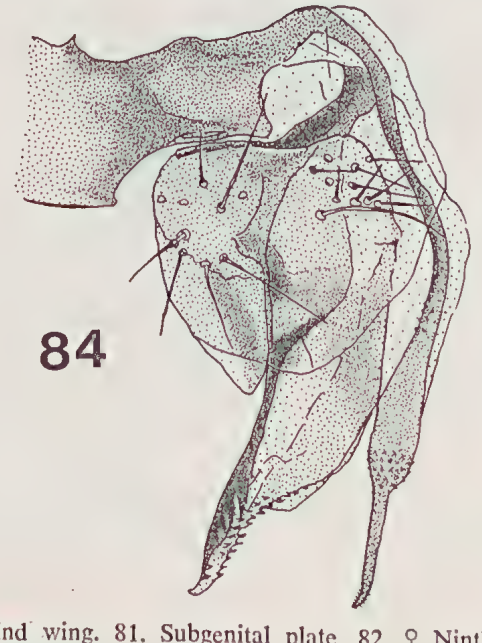
tubercle dark brown. First and second maxillary palp segments very pale brown, third and fourth segments dark brown. Mesothoracic notum dark brown except for pale brown parapsidal sutures and posterior borders of dorsal lobes. Femora brown with darker apical band; tibiae pale brown, darker at each end; tarsi dark brown. Fore wings hyaline with brown pattern (Fig. 74). Hind wings hyaline, veins brown. Abdomen pale with irregular lateral segmentally arranged marks; terminal structures very dark brown.

Morphology: Length of body: 3.1 mm. Median epicranial suture distinct, anterior arms not evident. Epistomial suture sinuous, curved forwards in middle, anterior to anteocellar spot. Length of flagellar segments: f_1: 0.90 mm; f_2: 0.84 mm. Antennae fine, flagellar setae up to three times as long as flagellar diameter. Eyes large, reaching a little above level of vertex. IO/D: 1.2; PO: 1.0. Eyes slightly emarginate opposite antenna base. Measurements of hind leg: F: 0.76 mm; T: 1.80 mm; t_1: 0.46 mm; t_2: 0.20 mm; rt: 2.3:1; ct: 21, 4. Tarsal segments long, ctendia large. Fore wing length: 4.9 mm; width: 1.6 mm. Fore wing. Fore wing (Fig. 74) with Sc ending in R. R_1 almost straight basad of hind angle of pterostigma; R_1 almost straight between hind angle and wing margin. Pterostigmal spurvein obvious. Rs and M fused for a short length. Veins somewhat evanescent at forking of Rs, second half of Cu_{1b}, basal section of Cu_{1a} and the third quarter of outer margin of discoidal cell. Cu_{1b} and M fused for a very short length. Hind margin of wing near base thin, rugose. A few small, fine setae on wing margin from proximal end of pterostigma to wing apex. Hind wing length: 4.0 mm; width: 1.2 mm. Hind wing with Rs and M fused for a length. A few small marginal setae between R_{2+3} and wing apex. Epiproct (Fig. 78) well sclerotized, less so laterally, with a pair of small, erect basal lobes. Paraprocts (Fig. 77) with large field of trichobothria and a lightly sclerotized, setose dome between trichobothria and the apical spur. Apical spur broad-based with sharply pointed,









FIGS. 79-84. *Tanystigma elongata* sp. n. 79. ♀ Fore wing. 80. ♀ Hind wing. 81. Subgenital plate. 82. ♀ Ninth sternite. 83. ♀ Epiproct. 84. Gonapophyses.

curved apex. Posterior margin of ninth tergite strongly sclerotized in middle section, the sclerotization tapering laterally. Hypandrium (Fig. 76) very heavily sclerotized with two inwardly curved, posterior projections which are laterally serrate between the bases of which the hind margin of the hypandrium is medially emarginate and bears a small median, rounded ventral sclerite. Phallosome (Fig. 75, tilted in preparation) consisting of two elongate, narrow, basally fused, distally divergent external parameres each with pointed, apical sclerite.

Female

Coloration (in alcohol): Body coloration as in male but with a median pale brown line on antedorsum of mesothorax and abdomen distinctly banded with brown. Antennae as in male but scape, pedicel and first two flagellar segments very pale. Third maxillary palp segment pale in distal half. Labrum pale, darker medially. Legs as in male. Fore wings (Fig. 79) hyaline with pattern more extensive than in male. Hind wings (Fig. 80) with some very pale brown colour.

Morphology: Length of body: 3.5 mm. Length of flagellar segments: f_1: 0.80 mm; f_2: 0.80 mm. Antennae fine, flagellar setae about as long as flagellar diameter, that is, setae are relatively much shorter than in male. Eyes much smaller than in male, not reaching level of vertex. IO/D: 2.2; PO: 0.8. Anterior ocellus much smaller than lateral ocelli. Epistomial suture sinuous anterior to ocellar tubercle. Measurements of hind leg: F: 0.72 mm; T: 1.56 mm; t_1: 0.38 mm; t_2: 0.20 mm; rt: 1.9:1; ct: 19, 0. Ctenidia small. Fore wing length: 4.1 mm; width: 1.4 mm. Fore wing (Fig. 79) similar to that of male but pterostigma a little broader, with margin both basad and distal of hind angle very slightly sinuous. Spurvein obvious. Areola postica joined to media by a short crossvein. Marginal setae as in male, between base of pterostigma and wing apex. Epiproct (Fig. 83). Subgenital plate (Fig. 81) with long, rounded posterior lobe with broad, irregular median band without pigment. Gonapophyses (Fig. 84). Sclerifications of ninth sternite (Fig. 82).

Material Examined: SOUTH AUSTRALIA. ♂ (holotype), ♀ (allotype), 20 km SE Port Augusta, Horrock's Pass, 17.vi.1979, G. A. Holloway. Paratypes: 1 ♀, Mt. Ohlssen Bragge, Wilpena Pound, 18.v.1981, G. and J. Holloway. 4 ♀, Germein Gorge, 20.v.1981, G. and J. Holloway.

Holotype, allotype and paratypes in the Australian Museum.

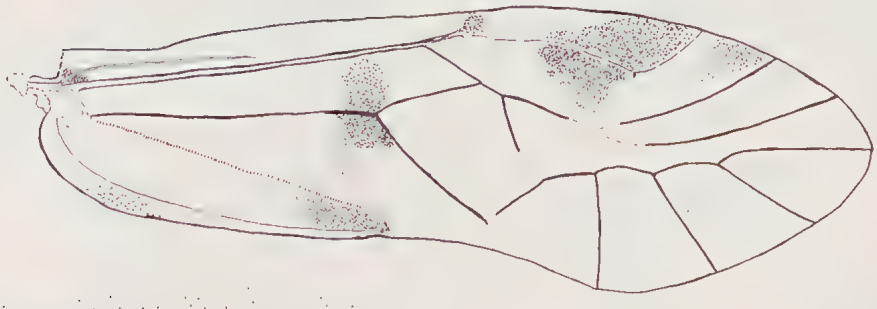
Discussion: Tanystigma elongata is the only species of the genus in which there are extensive wing markings in cells R_1, R_3 and R_5, Cu_1, Cu_2 and the discoidal cell. It is easily recognized on this feature.

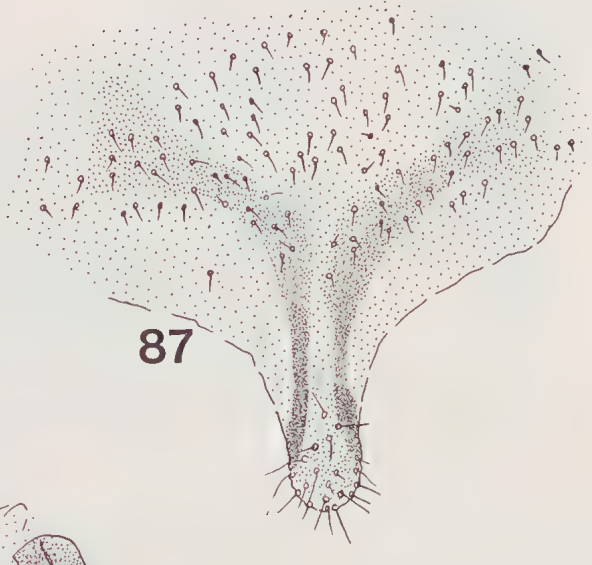
Tanystigma bifurcata sp. n.

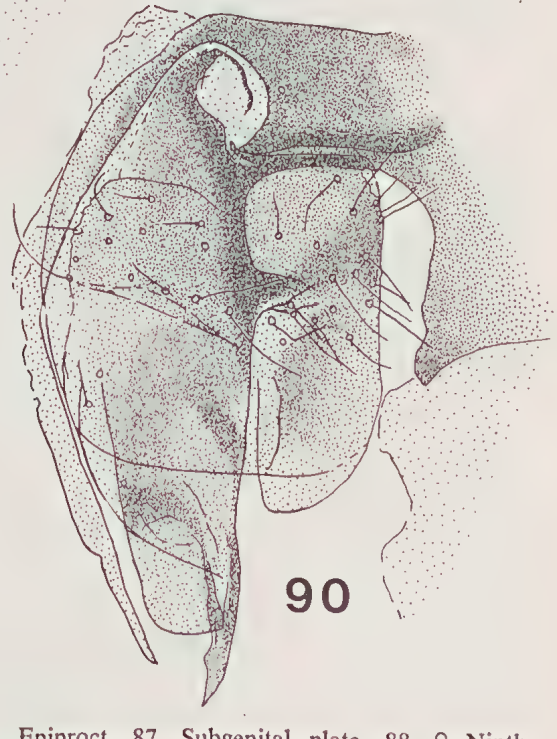
Female

Coloration (in alcohol): Head pale buff with dark brown spotting on either side of median epicranial suture, across back of vertex and adjacent to compound eyes. Area between epistomial suture and ocellar tubercle with ovoid brown mark enclosing a pale central spot. Postclypeus pale buff with fine parallel brown lines, very distinct, running forward from epistomial suture but not reaching anteclypeus. Labrum dark brown with median, anterior, semicircular pale area. Genae pale, not marked. Scape, pedicel and basal part of first flagellar segment brown, rest of antenna dark, almost black. Eyes black. Ocelli on very dark brown tubercle. First and second maxillary palp segments pale; third segment dark in basal half, dark distally; fourth segment dark brown. Mesothoracic notum dark brown with a median pale stripe; dorsal lobes with a small pale area near postero-lateral corner. Metanotum similar to mesonotum. Pleura dark brown with some paler areas. Coxae dark brown. Femora pale with some irregular brown marks and slight suggestion of preapical dark band. Tibiae pale brown. Tarsi brown. Fore wings (Fig. 85) hyaline with brown markings. Hind wings hyaline, with faint brownish patch behind distal end of Cu_2.

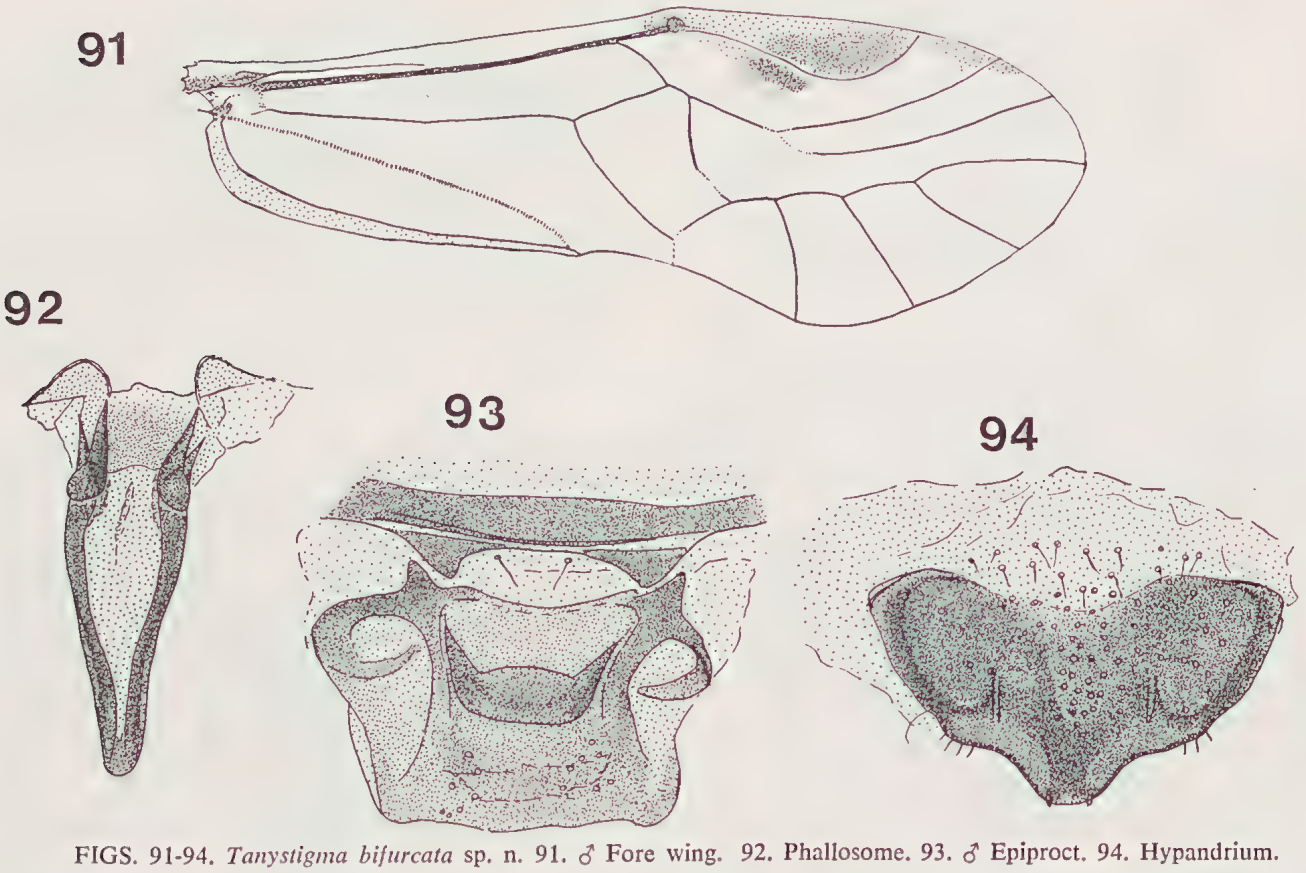
Morphology: Length of body: 3.5 mm. Head with well rounded vertex. Median epicranial suture very distinct. Postclypeus fairly bulbous. Lengths of flagellar segments: f_1: 0.64 mm; f_2: 0.52 mm. Eyes fairly large. IO/D: 1.1; PO: 0.80. Lateral ocelli very large, anterior ocellus small. Measurements of hind leg: F: 0.66 mm; T: 1.44 mm; t_1: 0.36 mm; t_2: 0.16 mm; rt: 2.3:1; ct: 18, 1. Fore wing length: 4.1 mm; width: 1.40 mm. Subcosta well developed basally, straight, becoming evanescent in costal cell. Stigmopophysis well developed, dome shaped. R_1 beyond stigmapophysis fine, i.e. hind margin of pterostigma fine. Spurvein very small. Postpterostigmal mark indistinct as it is of same colour as pigmented area but can be recognized by difference in texture from base to hind angle of pterostigma. Rs and M fused for a length. Rs and branches of Rs evanescent near bifurcation. M between Rs and Cu_{1a} strongly curved to give a concave outer margin to discoidal cell. Hind wing length: 3.2 mm; width: 1.0 mm. Sc evanescent in costal cell. Rs and M fused for a length. Wing margin between R_{2+3} and R_{4+5} with twelve well developed but short setae. Epiproct (Fig. 86). Paraproct (Fig. 89). Subgenital plate (Fig. 87). Gonapophyses (Fig. 90). Sclerifications of ninth sternite (Fig. 88).







FIGS. 85-90. *Tanystigma bifurcata* sp. n. 85. ♀ Fore wing. 86. ♀ Epiproct. 87. Subgenital plate. 88. ♀ Ninth sternite. 89. ♀ Paraproct. 90. Gonapophyses.



FIGS. 91-94. *Tanystigma bifurcata* sp. n. 91. ♂ Fore wing. 92. Phallosome. 93. ♂ Epiproct. 94. Hypandrium.

Male

Coloration (in alcohol): Body coloration as female. Fore wings (Fig. 91) hyaline. Hind wings hyaline without brownish area behind Cu_2.

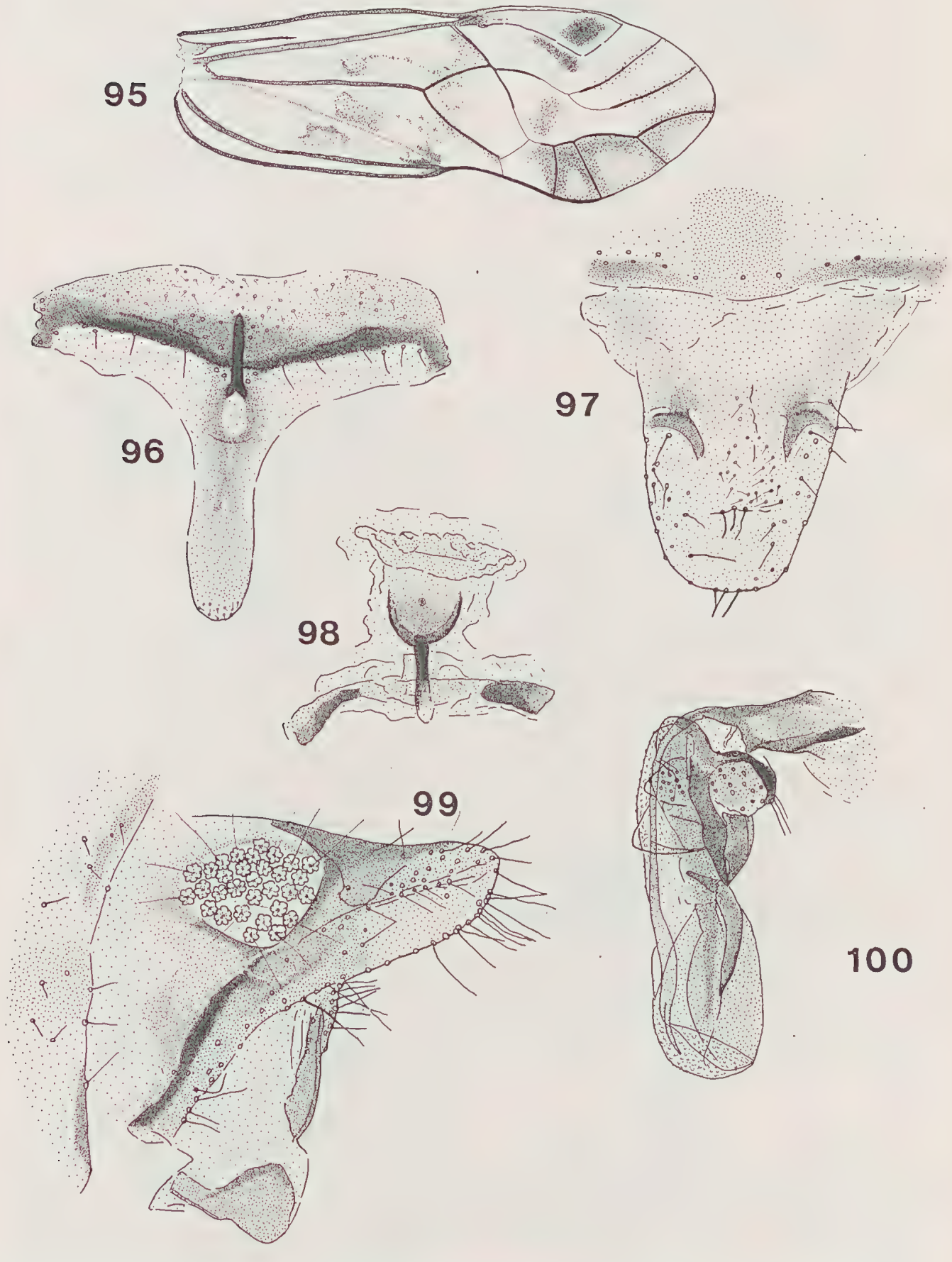
Morphology: Postclypeus not as bulbous as in female. Length of flagellar segments: f_1: 0.80 mm; f_2: 0.64 mm. Eyes very large, reaching just above level of vertex. IO/D: 1.0; PO: 0.94. Ocellar tubercle very well developed. Measurements of hind leg: F: 0.72 mm; T: 1.72 mm; t_1: 0.44 mm; t_2: 0.18 mm; rt: 2.4:1; ct: 18, 4. Legs long and thin. Fore wing length: 4.2 mm; width: 1.5 mm. Fore wing with indistinct pterostigmal spurvein but postpterostigmal mark well developed. M distad of separation from Rs strongly curved to give concave discoidal cell. Hind wing length: 3.1 mm; width: 1.1 mm. A few fine marginal setae between R_{2+3} and R_{4+5}. Epiproct (Fig. 93). Hind margin of ninth tergite well sclerotized with two small projections against which the epiproct articulates. Latero-ventral margin of ninth tergite on each side ends in a rounded apophysis. Hypandrium (Fig. 94). Phallosome (Fig. 92).

Material Examined: SOUTH AUSTRALIA. ♀ (holotype), ♂ (allotype), 18 km S Port Pirie, 7.v.1980, G. and J. Holloway. Paratypes: 7 ♀, 7 ♂, as holotype. 1 ♂, 1 ♀, 15 km N Port Broughton, 7.v.1980, G. and J. Holloway. 1 ♀, 4 km E Pinnaroo, 14.v.1980, G. and J. Holloway, 1 ♀, Alligator Gorge Rd., near Mt. Remarkable, Flinders Range, 17.vi.1979, G. A. Holloway, 1 ♂, Overland Corner, 15.vi.1979, G. A. Holloway.

Holotypes, allotype and paratypes in Australian Museum.

Discussion: Tanystigma bifurcata is very similar to *Psocidus notialis* Smithers, described from Western Australia. In both species the pterostigmal spurvein is very small, the hypandrium is symmetrical and somewhat bilobed and the phallosome has apically divided external parameres. In all other species of *Tanystigma* the external parameres are not so divided. The female genitalia differ in details from those of other species of *Tanystigma* and the extent of wing marking is considerably greater than in females of *Ps. notialis*, *T. paulum* (Smithers) and *T. tardipes* (Edwards). It is similar to that of *T. dubium* (New) but that species lacks the dark mark at the wing margin in cell R_1. *Ps. notialis* was not placed in *Tanystigma* when the latter genus was erected because of the bifurcation of the external parameres and the very small pterostigmal spurvein in both sexes. The discovery of *T. bifurcata*, however, indicates the inclusion of both in *Tanystigma*.

T. notialis (Smithers) *comb. nov.* and *T. bifurcata* do stand apart somewhat from the other species of the genus in having apically divided external parameres. They differ from each other in that *T. bifurcata* has a longer phallosome and the wing markings are less extensive in female *T. notialis* than they are in *T. bifurcata*. The statement made by me



FIGS 95-100. *Psocidus mouldsi* sp. n. 95. ♀ Fore wing. 96. Subgenital plate. 97. ♀ Epiproct. 98. ♀ Ninth sternite. 99. ♀ Paraproct. 100. Gonapophyses.

(Smithers, 1972) that "... *Ps. notialis* will probably be found to be congeneric with ..." *Clematostigma tardipes* Edwards and *C. maculiceps* Enderlein has not been supported by subsequent study of material of *C. maculiceps* (Smithers, 1983).

Psocidus mouldsi sp. n.

Female

Coloration (in alcohol): The colour pattern of this species is very similar to that of the males of *Blaste angusta*, described above. The spotting on the head is finer and the spots quite discrete and the ovoid mark anterior to the ocellar triangle is very conspicuous. The terminal structures of the abdomen are dark, the subgenital plate being very conspicuous owing to the heavily sclerotized T-shaped area. Fore wing (Fig. 95) hyaline, marked in various shades of brown.

Morphology: Length of body: 4.0 mm. Brachypterous, fore wings not reaching end of abdomen. Lengths of flagellar segments: f_1: 0.64 mm; f_2: 0.52 mm. Eyes not reaching vertex level. IO/D: 3.4; PO: 0.83. Measurements of hind leg: F: 0.64 mm; T: 1.84 mm; t_1: 0.48 mm; t_2: 0.20; rt: 2.4:1; ct: 21, 2. Fore wing length: 3.4 mm; width: 1.3 mm. Rs and M fused for a very short length. Third median cell narrow and almost parallel sided. Hind wing length: 2.9 mm; width: 1.0 mm. Rs and M fused for a short length. Epiproct (Fig. 97) lightly sclerotized with two, small, curved sclerotized areas about half way along epiproct and midway between middle and lateral edge of epiproct. Paraproct (Fig. 99) with two internal accessory sclerites attached to paraproct by membrane (displaced in illustration). Subgenital plate (Fig. 96) with heavily sclerotized transverse bar basad of posterior lobe; posterior lobe long with unusual pattern of sclerotization and pigment, having an ovoid, less sclerotized area near base of lobe. Gonapophyses (Fig. 100) with long, acuminate ventral valve; dorsal valve broad, rounded behind, constricted at the middle and supported by longitudinal sclerifications; external valve with dorsal, well sclerotized, posteriorly directed lobe. Sclerifications of ninth sternite (Fig. 98) more complex than usual in the genus.

Male

Unknown.

Material Examined: SOUTH AUSTRALIA. ♀ (holotype), 40 km E Nullarbor, 131°15′E, 31°25′S, 29.ix.1978, M. S. and B. J. Moulds. Paratype: 1 ♀, as holotype. Holotype and paratype in the Australian Museum.

The genus *Psocidus* was erected by Pearman (1934) to hold a large assemblage of species which had been described in the genus *Psocus* Latreille but which could not be retained in his restricted, redefinition of that genus. *Psocidus*, therefore, contains many unrelated species. With time it is hoped that they will be redistributed amongst present genera or logically placed in new genera. For the present *Psocidus* remains a "holding" genus.

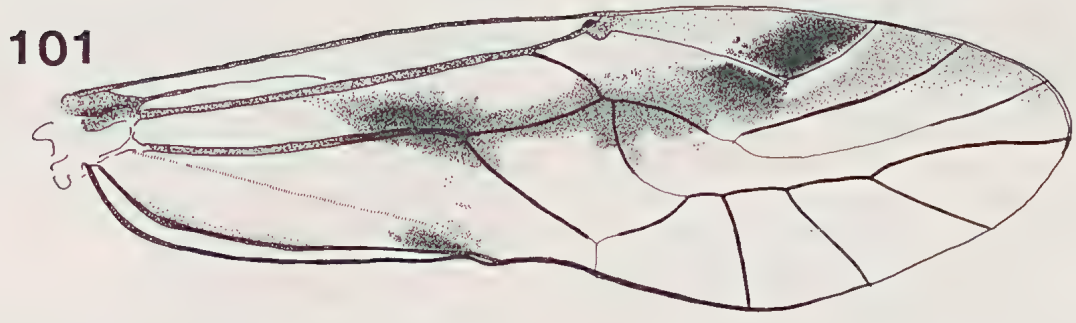
The relationship of *Ps. mouldsi* and *Ps. parilla* sp. n. (described below) are not known. They both stand apart from other species of the family and it is hoped that when further material, including males, is forthcoming, their position will be clarified.

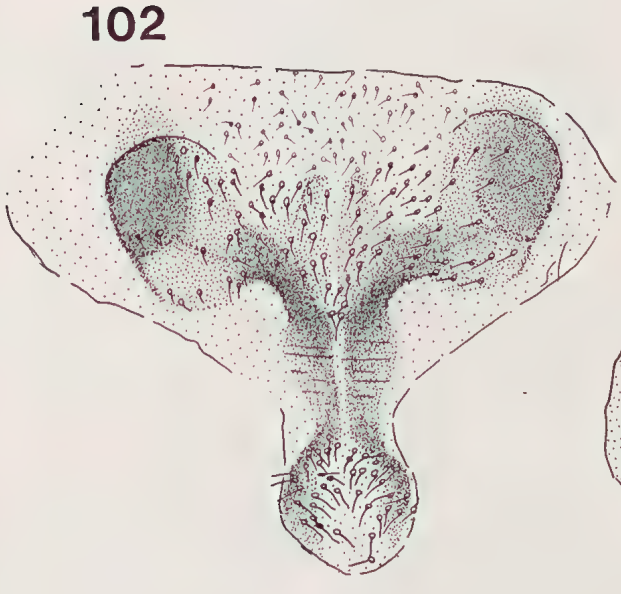
Psocidus parilla sp. n.

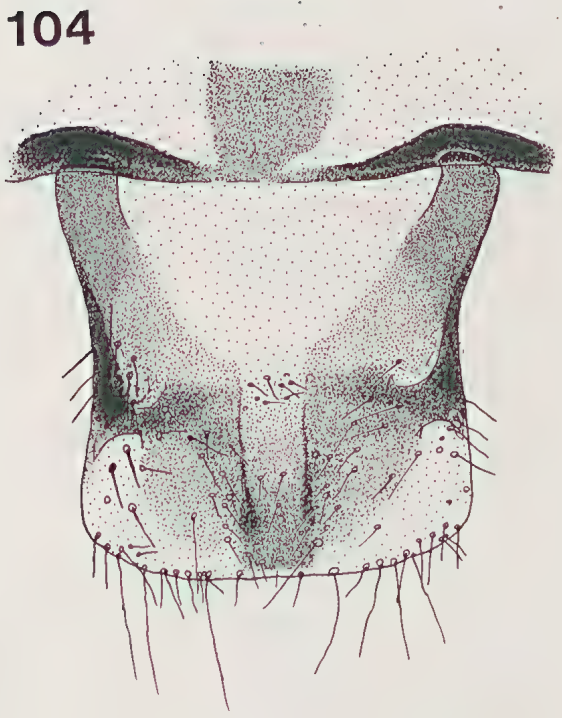
Female

Coloration (in alcohol): Head pale grey-brown with a double row of brown, irregular, confluent spots adjacent to compound eyes, across back of vertex and on either side of median epicranial suture; an oval brown mark anterior to ocellar tubercle; tubercle brown; postclypeal striations brown; genae not marked. Labrum dark brown. Antennae almost black. Eyes black. Maxillary palp with dark third and fourth segments; first and second segments pale. Mesothoracic notum shiny dark brown with pale parapsidal furrows, pale line along postero-lateral parts of lateral lobes and hind half of mesoscutellum pale. Pleura dark shiny brown. Coxae dark brown. Femora brown, darker along anterior and posterior sides with some irregular darker dorsal marks in distal quarter. Tibiae pale brown, darker at each end. Tarsi dark brown. Fore wings (Fig. 101) hyaline with pattern in various shades of brown. Hind wings hyaline with pale brown patch in distal quarter of cell Cu_2 adjacent to vein Cu_2 but not in distal corner of cell. Abdomen pale with dorsal and lateral irregular, segmentally arranged marks. Terminal structures very dark brown.

Morphology: Median epicranial suture distinct, anterior arms evanescent. Epistomial suture sinuous in middle, curving away from ocellar triangle in middle section. Length of flagellar segments: f_1: 0.92 mm; f_2: 0.68 mm. Eyes fairly large. IO/D: 2.5; PO: 0.9. Ocelli large, anterior ocellus smaller than lateral ocelli. Measurements of hind leg: F: 0.84 mm; T: 1.92 mm; t_1: 0.44 mm; t_2: 0.14 mm; rt: 3:1; ct: 19, 3. Fore wing length: 4.7 mm; width: 1.4 mm. Fore wing (Fig. 101) with Sc ending in R about half way between wing base and base of pterostigma. R_1 basad of hind angle of pterostigma very slightly curved to give a slightly concave pterostigma, beyond apex slightly convex. Rs and M fused for a length. M and Rs and Cu_{1a} curved to give fairly strongly concave discoidal cell. Cu_{1a} fused with M for a length, Cu_{1a} sinuous basad of fusion; basal section of Cu_{1a} and apex of areola postica at







FIGS. 101-105. *Psocidus parilla* sp. n. 101. ♀ Fore wing. 102. Subgenital plate. 103. ♀ Ninth sternite. 104. ♀ Epiproct. 105. Gonapophyses.

slight angle to one another. Fore wing glabrous. Hind wing length: 3.4 mm; width: 1.1 mm. Hind wing with Rs and M fused for a length. Costal cell near base broadened, the anterior margin slightly thickened and finely rugose in broad region. This part of costal margin would lie adjacent to a slight thickening of the hind margin of the fore wing in flight and these two structures probably assist in wing coupling. A few fine marginal setae between R_{2+3} and wing apex. Epiproct (Fig. 104). Subgenital plate (Fig. 102). Gonapophyses (Fig. 105). Sclerifications of ninth sternite (Fig. 103).

Male

Unknown.

Material Examined: SOUTH AUSTRALIA. ♀ (holotype), Pooginook, 5.vi.1979, A. Holloway. Paratypes: 2 ♀, as holotype. 2 ♀, 2 km E Parilla, 23.vi.1979, G. A. Holloway. 1 ♀, 4 km NW Murray Bridge, 22.v.1981, G., J. and A. Holloway.

Holotype and paratypes in the Australian Museum.

Discussion: See under *Psocidus mouldsi*.

Family MYOPSOCIDAE

Phlotodes australis (Brauer)

Psocus australis Brauer, 1865. *Ver. zool. -bot. Ges. Wien* 15: 908.

Psocus griseipennis McLachlan, 1866. *Trans. ent. Soc. Lond.* (3) 5: 348.

Myopsocus griseipennis (McL.). McLachlan, 1866. *Trans. ent. Soc. Lond.* (3) 5: 352.

Myopsocus novaezealandiae Kolbe, 1883. *Ent. Nachr.* 9: 145.

Psocus zelandicus Hudson, 1892. *Manual of New Zealand Entomology*, p. 107; Pl. XVI, Figs. 2, 2a.

Phlotodes griseipennis (McL.). Enderlein, 1910. *S.B. Ges. naturf. Fr. Berl.* 1910 (2): 67.

!*Myopsocus griseipennis* (McL.) Edwards, 1950. *Pap. Proc. R. Soc. Tasm.* 1949: 104, Figs. 26-32.

Phlotodes australis (Brauer). Smithers, 1975. *Aust. ent. Mag.* 2 (4): 76.

Material Examined: SOUTH AUSTRALIA. 1 ♂ Belair, 28.ix.1935, H. Womersley.

This species has been recorded from all states except the Northern Territory.

Phlotodes hickmani (Smithers)

Myopsocus australis (Brauer). Hickman, 1934. *Pap. Proc. R. Soc. Tasm.* 1933: 85.

Myopsocus griseipennis (McL.). Edwards, 1950. *Pap. Proc. R. Soc. Tasm.* 1949: 104, Figs. 26-32.

Myopsocus hickmani Smithers, 1964. *Proc. R. ent. Soc. Lond.* (*B*) 33: 135.

Phlotodes hickmani (Sm.). Smithers, 1971. *J. Aust. ent. Soc.* 10 (1): 24.

Material Examined: SOUTH AUSTRALIA. 3 ♀, Morialta, 14.v.1940, H. Womersley. 6 ♀, Magill, 6.ii.1884, Tepper.

P. hickmani is known from Tasmania and Victoria.

ACKNOWLEDGEMENTS

I would like to thank Professor V. V. Hickman for material of Tasmanian species of Psocoptera for comparison with South Australian material; the several collectors who provided other material, especially Geoffrey, Janet and Andrew Holloway and Max and Barbara Moulds; Gordon Gross for arranging the loan of South Australian Museum material; the Director of the South Australian National Parks and Wildlife Service for permission for work to be done in areas under his jurisdiction; the Australian Research Grants Committee for providing funds in support of studies of the Psocoptera of the Melanesian arcs and possible source areas; and Martyn Robinson for preparing the illustrations to this paper.

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HELMINTH TYPE-SPECIMENS IN THE SOUTH AUSTRALIAN MUSEUM
II. ACANTHOCEPHALA AND CESTODA

by

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South Australian Museum, Adelaide, South Australia 5000

ABSTRACT

SMALES, L. R. 1983. Helminth type-specimens in the South Australian Museum. II. Acanthocephala and Cestoda. *Rec. S. Aust. Mus.* **18**(21): 493-501.

Type-specimens of 16 species of Acanthocephala and 80 of Cestoda are catalogued. All except two are from Australian or Antarctic hosts. Species are listing the helminth types held by the South Aus- of the genus. Where a name change has occurred the most recent acceptable name is included.

INTRODUCTION

This is the second of an intended series of papers listing the helminth types held by the South Australian Museum and the Australian Helminthological Collection, currently housed in the Museum.

Species are arranged alphabetically according to the original name of the genus. Full synonymies are not given, but where a name change has occurred, the most recent acceptable name is given together with the relevant reference. Host-species names are those used in the original descriptions. Types held in the South Australian Museum have registration numbers prefixed by V. Types held in the Australian Helminthological Collection have registration numbers prefixed by AHC or AHC S.

The following abbreviations are used in the text. A.A.E. = Australian Antarctic Expedition, 1911-1914; BANZARE = British Australia and New Zealand Antarctic Research Expedition, 1929-1931; SAM = South Australian Museum; AHC = Australian Helminthological Collection; N.T. = Northern Territory; N.S.W. = New South Wales; Qld = Queensland; S.A. = South Australia; Tas. = Tasmania; Vic. = Victoria; W.A. = Western Australia.

PHYLUM ACANTHOCEPHALA

The earliest descriptions of type material held at the South Australian Museum are those of T. H. Johnston, Professor of Zoology, the University of Adelaide, Honorary Director of the Museum 1928-1931, and Chairman of the Museum Board 1940-1951. Later descriptions are by S. J. Edmonds, Honorary Associate of the Museum, who is the foremost Australian authority on Acanthocephala and continues active research into the taxonomy of the group.

Acanthocephalans are parasitic, wormlike pseudocoelomates that lack a digestive system. A diagnostic feature of the group is the presence of an anteriorly placed, invaginable proboscis or introvert, always armed with hooks.

The adult parasites infest the digestive tract of vertebrates. Unless otherwise stated specimens listed below were dissected from the small intestine.

Arhythmorhynchus limosae Edmonds, 1971
Trans. R. Soc. S. Aust. **95** (2): 58-60.
Paratypes V2185-9, 3 ♂, 2 ♀, one in fragments from *Limosa lapponica,* Townsville, Qld., collector A. J. Bearup, 28/1/59.

Arhythmorhynchus frassoni Molin, 1858
Trans. Roy. Soc. S. Aust. **74** (1): 3 (Johnston & Edmonds, 1951), now *A. Johnstoni* (Molin, 1858 sensu Johnston & Edmonds, 1951), Golvan, 1960.
Paratypes V2183-4, both ♂, one in fragments, from *Numenius cyanopus,* Gladstone, Qld., collector T. H. Johnston, 1910.
Note: Golvan, 1960 made the Australian specimens, described by Johnston & Edmonds, 1951, a new species but gave no reasons for his action.

Corynosoma australe Johnston, 1937
Proc. Linn. Soc. N.S.W. **62** (1/2): 13-16.
Syntypes V2227-9, 4 ♂ and 2 ♀, from *Arctocephalus forsteri,* Pearson Is., S.A., collector J. B. Cleland, January 1923.
Note: Johnston, 1937, recorded the type as being deposited in SAM but this does not appear to have been done. Johnston & Best, 1942 mention that the type host for *C. australe* was incorrectly identified and should have been listed as *Neophoca cinerea.*

Corynosoma cetaceum Johnston & Best, 1942
Trans. R. Soc. S. Aust. **66** (2): 250-2.
Holotype ♂ V964, allotype ♀ V963, from *Delphinus delphis,* Gulf St Vincent, S.A., collector probably T. H. Johnston, date unknown.

Echinorhynchus hylae Johnston, 1914
Proc. R. Soc. Qld. **26**: 83.

* Present address: Gippsland Institute of Advanced Education, P.O. Box 42, Churchill, Victoria 3845.

Now *Porrorchis hylae* (Johnston, 1914) Schmidt & Kuntz, 1967.
Type V2540, cotype V2539, from *Hylae caerulea* encysted in the liver. Collector probably T. H. Johnston, date unknown.
Locality: near Brisbane, Qld.

Echinorhynchus menurae Johnston, 1912
Proc. R. Soc. Qld. **24**: 83.
Now *Plagiorhynchus menurae* (Johnston, 1912) Golvan, 1956.
Type V2438, from *Menura superba,* near Gosford, N.S.W., collector probably T. H. Johnston, date unknown.
Note: Johnston, 1914 recorded that the types of *E. hylae* and *E. menurae* had been deposited in the Queensland Museum, Brisbane. However, on examination, specimens registered in SAM were found to be Johnston's original material.

Echinorhynchus zanchlorhynchi Johnston & Best, 1937
A.A.E. Rep. Ser. C **10** (2): 12-3.
Holotype ♀ V2200, from *Zanchlorhynchus spinifer,* Macquarie Island, collected during A.A.E. 1911-1914.

Empodius alecturae Johnston & Edmonds, 1947
Rec. S. Aust. Mus. **8** (4): 557-61.
Now *Mediorhynchus alecturae* (Johnston & Edmonds, 1947) Schmidt & Kuntz 1977.
Syntypes V2470-8, from *Alectura lathami,* Eidsvold, Burnett River, Qld., collector T. L. Bancroft, date unknown.

Gordiorhynchus bancrofti Johnston & Best, 1943
Trans. R. Soc. S. Aust. **67** (2): 226-9.
Now *Centrorhynchus bancrofti* (Johnston & Best, 1943) Golvan, 1960.
Holotype ♀ V2210, cotype ♀ V2211, from *Ninox strenua,* Eidsvold, Burnett River, Qld., collector T. L. Bancroft, date unknown.

Gordiorhynchus falconis Johnston & Best, 1943
Trans. R. Soc. S. Aust. **67** (2): 229-30.
Now *Centrorhynchus falconis* (Johnston & Best, 1943) Golvan, 1960.
Holotype ♂ V2212, from *Falco berigora,* Hermannsburg, N.T., collector T. H. Johnston, date unknown.

Illiosentis furcatus Van Cleave & Linicome, 1939
BANZARE Rep. Ser. B **6** (5): 91-8. (Edmonds, 1957).
Now *Illiosentis edmondsi* (Van Cleave & Linicome, 1939 sensu Edmonds, 1957) Golvan, 1960.
Lectotype ♀ V2336, from *Upenichthys porosus.* Station 76, continental shelf east of Albany, W.A., collector T. H. Johnston, 1929-1931.
Note: The lectotype here designated was selected from the original material by Edmonds.

Longicollum pagrosomi Yamaguti, 1935
Trans. R. Soc. S. Aust. **74** (1): 3-5. (Johnston & Edmonds, 1951.)
Now *Longicollum edmondsi* (Yamaguti, 1935 sensu Johnston & Edmonds, 1951) Golvan, 1960.
Holotype ♂, V2349, from *Mylio australis,* Brisbane River, Qld., probably collected by T. H. Johnston in 1918.

Mediorhynchus corcoracis Johnston & Edmonds, 1951
Trans. R. Soc. Aust. **74** (1): 1-3.
Holotype ♂ V2502, allotype ♀ V2501, from *Corcorax melanorhampus,* Upper Burnett River, Qld., collector T. L. Bancroft, date unknown.

Neoechinorhynchus aldrichettae Edmonds, 1971
Trans. R. Soc. S. Aust. **95** (2): 55-8.
From *Aldrichetta forsteri* (posterior gut), Port Pirie, S.A., collector L. M. Angel, Port Pirie, S.A., date unknown.
Paratypes ♂ V2125, ♀ V2126.

Pararhadinorhynchus coorongensis Edmonds, 1973
Trans. R. Soc. S. Aust. **97** (1): 19-21.
Holotype ♂ V2392, allotype ♀ V2393, from *Aldrichetta forsteri,* Coorong, S.A., collector J. Harris, 1962.
Paratypes V2381-84, 3 ♂ and 1 ♀.
Note: Edmonds, 1973 recorded the type specimens (♂ and ♀) as being deposited in the Australian Museum but examination of specimens revealed that both primary and secondary types had been registered at SAM.

Pararhadinorhynchus mugilis Johnston & Edmonds, 1947
Trans. R. Soc. S. Aust. **71** (1): 15-7.
Holotype ♂ V2399, from *Mugil cephalus,* Port Willunga, S.A., collector T. H. Johnston, 1939.
Note: Paratypes 2400-05, 5 ♀ showing introvert well extended, genital complex and eggs, 1 ♂ showing cement glands and genital ganglion.

Polymorphus bizurae Johnston & Edmonds, 1948
Trans. R. Soc. S. Aust. **72** (1): 71-4.
Holotype ♂ V2444, allotype ♀ V2447, from *Biziura lobata,* Tailem Bend, S.A., collectors G. G. & B. Jaensch and L. Ellis, date unknown.

Pseudoporrorchis hydromuris Edmonds, 1957
Trans. R. Soc. S. Aust. **80**: 77-8.
From *Hydromys chrysogaster,* Innisfail, Qld., collector N. G. Elliot, 10/10/55.

Note: Type specimens do not appear to have been deposited in SAM. There is additional material V2573-9, collector B. Ewers from Port Moresby, Papua New Guinea.

PHYLUM PLATYHELMINTHES

CLASS CESTODA

Specimens described by G. Krefft, 1873, are the oldest material in the type collection. Krefft's work was subsequently revised by T. H. Johnston. When Johnston arrived in Adelaide he brought with him much of the material which had been collected and described by him between 1909 and 1916 as well as some of Krefft's collection. Both T. H. and S. J. Johnston worked on Australian cestode material during the same period. All the species designated Johnston were described by T. H. Johnston. Continued interest has been shown in the Australian cestoda by a small number of workers since then. Some 80 type specimens from hosts collected throughout Australia and from Antarctic waters have been registered at the SAM or in the AHC.

Unless otherwise stated specimens listed below were dissected from the intestine of the vertebrate host.

Acanthotaenia tidswelli Johnston, 1909
Proc. R. Soc. N.S.W., **43**: 103-16.

Paratypes AHC 2051, from *Varanus varius,* near Bathurst, N.S.W., collector T. H. Johnston, date unknown.

Anomotaenia asymmetrica Johnston, 1913
Rep. Aust. Inst. Trop. Med. 1911: 81-2.

Paratype AHC S95, from *Herodias timorensis,* Townsville, Qld., from the collection of A. Breinl, date unknown.

Anomotaenia rhinocheti Johnston, 1911c
Proc. Linn. Soc. N.S.W. **36** (1): 70-4.

Cotype AHC S82, from *Rhinochetus jubatus,* collected in New Caledonia, held in captivity in Sydney for six months, collector H. E. Finck, date unknown.

Anthobothrium sexorchidum Williams, 1964
Parasitology **54**: 741-3.

Holotype V1061, from *Taeniura lymna,* Heron Is., off Rockhampton, Qld., collector J. Pearson, June 1956.

Balanotaenia bancrofti Johnston, 1924
Proc. Linn. Soc. N.S.W. **49** (3): 339-47.

Paratypes V1437-43, including serial sections, from *Tandanus tandanus,* Eidsvold, Burnett Rd., Qld., collectors T. L. & M. J. Bancroft, date unknown.

Balanotaenia newguinensis Mackiewicz & Blair, 1978
J. Helminthol. **52**: 201-3.

Paratypes V1158-59 from *Tandanus brevidorsalis,* Brown R., near Port Moresby, Papua New Guinea, collector D. Blair, date unknown.

Bancroftiella ardea Johnston, 1913
Rep. Aust. Inst. Trop. Med. 1911: 85-6.
Now *Parvitaenia ardea* (Johnston, 1913) Baer & Bona, 1960.

Lectotype V1673, paralectotypes AHC S309-11, from *Nycticorax caledonicus,* Townsville, Qld., from the collection of A. Breinl, date unknown.

Note: The lectotype, selected by Bona (1975), was labelled in T. H. Johnston's handwriting *Nycticorax caledonicus,* Glasshouse Mts., S. Qld., collector B. B. Taylor.

Bancroftiella tenuis Johnston, 1911a
Proc. Linn. Soc. N.S.W. **36** (1): 50-7.
Cotype AHC S92, from *Macropus ualabatus,* collector A. S. Le Souëf, date unknown.

Note: Other species in this genus known only from birds. Johnston (1913) observed that there was no reason to doubt the accuracy of the collection data.

Bertiella foederata Beveridge, 1976
Aust. J. Zool. Suppl. Ser. **44**: 14-16.
Holotype V797, paratypes V798, 799, holotype sections AHC S968, from *Pseudocheirus peregrinus,* Inverleigh, Vic., collector I. Beveridge, 1/6/75.

Berteiella mawsonae Beveridge, 1976
Aust. J. Zool. Suppl. Ser. **44**: 16-18.
Holotype V794, paratype V795, from *Schoinobates volans,* Dartmouth, Vic., 20/1/74, collector I. Beveridge.

Bertiella petaurina Beveridge, 1976
Aust. J. Zool. Suppl. Ser. **44**: 21-3.
Holotype V796, from *Schoinobates volans,* Tumut, N.S.W., collector R. Smith, 1964.

Biacetabulum tandani Johnston & Muirhead, 1950
Rec. S. Aust. Mus. **9** (3): 346-8.
Holotype V847, from *Tandanus tandanus,* Tailem Bend and Murray Bridge, S.A., collectors G. G. Jaensch, L. Ellis and L. M. Angel, 1947-48.

Bothridium pythonis var. *parvum* Johnston, 1913
Rep. Aust. Inst. Trop. Med. 1911: 91-3.
Type material AHC 2054, from *Varanus varius,* Townsville, Qld., collector A. Breinl, date unknown.

Bothriocephalus kerguelensis Prudhoe, 1969
BANZARE rep. Ser. B **8** (9): 173-4.
Cotypes V115-27, 567-9, from *Notothenia cyanobrancha,* Royal Sound, Kerguelen, 20/10/29, 10/2/30; *Notothena rossi* Station 64, Kerguelen, collector T. H. Johnston.

Note: Prudhoe did not designate type host, or locality of type in any of the cestodes he described from the BANZARE Expedition for 1929-1931. All the material sent to SAM was designated cotype material by the author.

Calostaurus mundayi Beveridge, 1975
J. Helminthol. **49**: 133-35.
Paratype V55, from *Potorous apicalis,* Launceston, Tas., collector B. L. Munday, date unknown.

Calostaurus thylogale Beveridge, 1975
J. Helminthol. **49**: 129-33.
Paratype V54, from *Thylogale billiardieri,* Launceston, Tas., collector B. L. Munday, date unknown.

Capiuterilepis australiensis Schmidt, 1972
J. Parasitol. **58** (6): 1089-91.
Holotype V1090, paratype V1091-02, from *Anthochoera carunculata,* Nicholl's Reserve, S.A., collected by SAM, July 1971.

Capiuterilepis meliphagicola Schmidt, 1972
J. Parasitol. **58** (6): 1091-2.
Holotype V1108, paratype V1109-10, from *Philemon corniculatus,* Caloundra, Qld., collector probably T. H. Johnston, 1920.

Caryoaustralis sprenti Mackiewicz & Blair, 1980
Proc. Helm. Soc. Wash. **47** (2): 169-72.
Paratype V1899, from *Tandanus ater,* Annan R., Helemvale, Qld., probable collector D. Blair, date unknown.

Choanotaenia meliphagidarum Johnston, 1911c
Proc. Linn. Soc. N.S.W. **36** (1): 58-70.
Now *Pseudochoanotaenia meliphagidarum* (Johnston, 1911) Schmidt, 1972.
Cotypes AHC S87, 88, 89, 389, from *Ptilotis leucotis,* Sydney and Hawkesbury District, N.S.W., collectors T. H. Johnston & J. B. Cleland, 1909.
Note: Although designated cotype by T. H. Johnston some of the material in the AHC was collected from *Meliornis sericea* and *Meliornis novaehollandiae* as well as *Ptilotis leucotis.*

Choanotaenia taylori Johnston, 1912a
Mem. Qld. Mus. **1**: 213.
Cotype AHC S90, from *Malurus cyanoclamys,* near Adelaide, S.A., collector J. B. Cleland, 1910.

Cittotaenia bancrofti Johnston, 1912c
Proc. R. Soc. Qld. **24**: 68-9.
Now *Progamotaenia bancrofti* (Johnston, 1912) Nybelin, 1917 after Beveridge, 1980.
Holotype (sectioned material) V2121, from *Onychogale frenata,* Burnett R., Qld., collector T. L. Bancroft, date unknown.

Cittotaenia lagorchestis Lewis, 1914
Proc. Zool. Soc., Lond. 1914: 420.
Now *Progamotaenia lagorchestis* (Lewis, 1914) Nybelin 1917 after Beveridge & Thompson, 1979.
Neotypes V1322, 1323, Barrow Is., W.A., collector L. Hemsley.
Note: The original type material from *Lagorchestes conspicillatus* collected on Hermit Is., Montebello Group, W.A. by P. D. Montague ?1914 has been reported as lost (Beveridge, 1976; Beveridge & Thompson, 1979). Two similar yet distinct species have been confused under the name *P. lagorchestis* (Lewis, 1914). The original species is redescribed by Beveridge & Thompson (1979) as above. The specimens described by Beveridge in 1976 represent a new species designated *P. thylogale* by Beveridge & Thompson (1979).

Cittotaenia tachyglossi Johnston, 1913
Rep. Aust. Inst. Trop. Med. 1911: 77-8.
Now *Echidnotaenia tachyglossi* (Johnston, 1913) Beveridge, 1980a. Syntypes V1303-14, including sectioned material, from *Tachyglossus aculeatus,* Townsville, Qld., from the collection of A. Breinl, date unknown.

Cyclorchida omalanchristota Wedl, 1855
Rep. Aust. Inst. Trop. Med. 1911: 86-8. (Johnston, 1913.)
Now *C. o. australiensis* (Wedl, 1855 sensu Johnston, 1913). Bona, 1975.
Syntypes S312, from *Platalea regia,* Townsville, Qld., from the collection of A. Breinl, date unknown.

Davainea cacatuina Johnston, 1913
Rep. Aust. Inst. Trop. Med. 1911: 79-80.
Now *Raillietina cacatuina* (Johnston, 1913) Yamaguiti, 1959.
Paratypes V1081-4, from *Cacatua galerita,* Townsville, Qld., from the collection of A. Breinl, date unknown.

Davainea himantopodis Johnston, 1911c
Proc. Linn. Soc. N.S.W. **36** (1): 75-9.
Cotypes AHC S83, from *Himantopus leucocephalus,* Tailem Bend, S.A., collector J. B. Cleland, 1910.

Dendrouterina australiensis Baer & Bona, 1960
Boll. Instit. Mus. Zool. Univ. Torino **6** (4): 12-3.
Holotype V1676 including sectional material, from "grey heron", Swan Reach, S.A., collector T. H. Johnston, 15/12/37.
Note: Baer & Bona (1960) record this from Australian material labelled "Grey Heron" *Ardea pacifica* Latham? At the time of the collection "Grey Heron" was often used in S.A. for *Ardea novaehollandiae* and in T. H. Johnston's dissection notes there is recorded "Grey Heron" *Notophoyx novaehollandiae. N. pacifica* was referred to by Johnston as the Pacific Heron which is a much rarer bird at Swan Reach.

Dilepis bancrofti Johnston, 1912a
Mem. Qld. Mus. **1**: 21-2.
Now *Hemiparonia bancrofti* (Johnston, 1912) Schmidt, 1972.
Type and cotype AHC S91 including sectioned material, from *Platycercus eximius,* collector T. H. Johnston, date unknown.

Diphyllobothrium arctocephalinum Johnston, 1937
Proc. Linn. Soc. N.S.W. **62** (1): 9-13.
Holotype V13, from *Arctocephalus forsteri,* Pearson Is., collector J. B. Cleland, 1923.
Note: Host collection data are identical with that for the host of *Corynosoma australe.* Johnson and Best (1942) record that the type host was incorrectly identified and should be regarded as *Neophoca cinerea.*

Echinobothrium heronensis Williams, 1964
Parasitology **54**: 737-40.
Paratype V1066, holotype V1060, from *Taenuira lyma,* Heron Is., off Rockhampton, Qld., collector J. Pearson, June 1956.

Eutetrarhynchus australis Prudhoe, 1969
BANZARE Rep. Ser. B **8** (9): 176-7.
Cotypes V143, 144, 605, from *Mustelus antarcticus,* Hobart, Tas., collector T. H. Johnston, November 1930.

Hymenolepis aklei Beveridge & Barker, 1975
J. Helminthol. **49**: 220-4.
Paratypes V68-70, holotypes V67, from *Antechinus stuartii,* Powelltown, Vic., collected by the authors 17/8/74.

Hymenolepis bradleyi Beveridge & Barker, 1975
J. Helminthol. **49**: 224-6.
Paratypes V72-4, holotype V71, from *Antechinus stuartii,* Powelltown, Vic., collected by the authors 23/3/74.

Hymenolepis ellisi Johnston & Clark, 1948a
Trans. R. Soc. S. Aust. **72** (1): 81-2.
Holotype V2803, from *Pelecanus conspicillatus,* collectors G. G., Fred & B. Jaensch and L. Ellis, date unknown. Locality: Tailem Bend, S.A.

Hymenolepis jaenschi Johnston & Clark, 1948a
Trans. R. Soc. S. Aust. **72** (1): 79-81.
Holotype V2804, from *Pelecanus conspicillatus,* Tailem Bend, S.A., collectors G. G., Fred and B. Jaensch and L. Ellis, date unknown.

Hymenolepis murrayensis Johnston & Clark, 1948a
Trans. R. Soc. S. Aust. **72** (1): 77-9.
Holotype V2802, from *Pelecanus conspicillatus,* Tailem Bend, S.A., collectors G. G., Fred and B. Jaensch and L. Ellis, date unknown.

Lapwingia adelaidae Schmidt, 1972
J Parasitol. **58** (6): 1085-7.
Paratypes V1105-7, holotype V1104, from *Lobibyx novaehollandiae,* Townsville, Qld., collector and date unknown (probably from A. Breinl's collection 1910 to 1913).

Lateriporus mawsoni Prudhoe, 1969
BANZARE Rep. Ser. B **8** (9): 190-1.
Cotypes V362-71, from *Chionis minor,* Kerguelen Is., collector T. H. Johnston, 17/11/29.
Note: Several other collection sites are listed. Also recorded from *Chionis minor crozettensis,* Possession Island, Crozets, 3/11/29.

Megalonchos dubius Prudhoe, 1969
BANZARE Rep. Ser. B **8** (9): 180-2.
Cotypes V156-8, from *Mustelus antarcticus,* Hobart, Tas., collector T. H. Johnston, November 1930.

Megalonchos musteli Prudhoe, 1969
BANZARE Rep. Ser. B **8** (9): 179-80.
Cotypes V152-5, from *Mustelus antarcticus,* Hobart, Tas., collector T. H. Johnston, November 1930.

Moniezia diaphana Zschokke, 1907
Zentralbl. Backteriol. Parasitenk. **44**: 261-64.
Now *Progamotaenia diaphana* (Zschokke, 1907) Baer, 1927 after Beveridge, 1976.
Syntypes V2122, from *Lasiorhinus latifrons* bile ducts, probably Adelaide, S.A., collector E. Angus Johnston, date unknown.
Note: The material registered in SAM is thought by Beveridge (1976 and 1980b) to be some of the original material described by Zschokke (1907). The material was mounted by T. H. Johnston and labelled, in his handwriting, "part of material examined by Zschokke and Angus Johnston". There were no collection data given by Zschokke in the original description. The host name was recorded as *Phascolomys vombat* now a synonym of *Vombatus ursinus.* Beveridge (1980) believes this identification to be in error with the type host being *Lasiorhinus latifrons.*

Notylocestus major Johnston & Muirhead, 1950
Rec. S. Aust. Mus. **9** (3): 340-4.
Holotype V854, paratype V855, from *Tandanus tandanus,* Murray Bridge, S.A., collector L. M. Angel, December 1947.

Notylocestus minor Johnston & Muirhead, 1950
Rec. S. Aust. Mus. **9** (3): 344-6.
Holotype V856, from *Tandanus tandanus,* Murray Bridge, S.A., collector L. M. Angel, December 1947.

Oochoristica antechini Beveridge, 1977
J. Helminthol. **51**: 32-5.
Holotype V818, from *Antechinus macdonnellensis,* 27 km west of Refrigerator Well, Tanami Rd., N.T., collector P. Woolley, July 1975.

Oochoristica eremophila Beveridge, 1977
J. Helminthol. **51**: 35-8.

Holotype V828, paratypes V829-35, from *Antechinus rosamundae,* Woodstock Stn., via Marble Bar, W.A., collector P. Woolley, November, 1975.

Ophiotaenia hylae Johnston, 1912c
Proc. R. Soc. Qld. **24**: 63-4.

Cotypes AHC S86, from *Hyla aurea*, Sydney, N.S.W., collector S. J. Johnston, date unknown.

Ophiotaenia longmani Johnston, 1916
Mem. Qld. Mus. **5**: 186-94.

Cotypes AHC S85, S523, from *Aspidiotes ramsayi*, Yeulba, Western Qld., collector H. A. Longman, date unknown.

Paramonezia johnstoni Beveridge, 1976
Aust. J. Zool. Suppl. Ser. **44**: 31-4.

Holotype V760, paratypes V761-5, from *Vombatus ursinus,* Forester R., Tas., collector B. L. Munday, 28/4/72.

Parabothriocephalus johnstoni Prudhoe, 1969
BANZARE Rep. B **8** (9): 174-5.

Cotypes V128-36, 570 from *Coryphaenides whitsoni*, 330 fathoms, 66° 24′S, 59° 09′E, collector T. H. Johnston, 7/1/30.

Parvitaenia clavipera Baer & Bona, 1960
Boll. Inst. Mus. Zool. Univ. Torino **6** (4): 3.

Holotype V1675, from *Ardea novaehollandiae,* Townsville, Qld., collector not known, possibly A. Breinl 1910-1913.

Note: This slide labelled *Bancroftiella glandularis* (Fuhrmann), in T. H. Johnson's handwriting.

Parvitaenia paracyclorchida Baer & Bona, 1960
Boll. Inst. Mus. Univ. Torino **6** (4): 1-3 & 44.

Holotype V1674, from *Ardea novaehollandiae,* Wamberal, N.S.W., collector S. J. Johnston, date unknown.

Note: This slide labelled *Bancroftiella glandularis* in T. H. Johnston's handwriting.

Phascolotaenia comani Beveridge, 1976
Aust. J. Zool. Suppl. Ser. **44**: 35-7.

Holotype V766, paratypes V767-8, from *Vombatus ursinus,* Taggerty, Vic., collector B. J. Coman, 19/7/71.

Polyonchobothrium scleropagis Blair, 1978
J. Helminthol. **52** (2): 147-53.

Holotype V1160, paratypes V1161-5, from *Scleropages leichardti,* Wenlock R., Cape York Pen., Qld., collector D. Blair, 8/7/75.

Progamotaenia aepyprymni Beveridge, 1976
Aust. J. Zool. Suppl. Ser. **44**: 40-1.

Holotype V772, from *Aepyprymnus rufscens,* Burnett R., Qld., collector T. L. Bancroft, February 1912.

Progamotaenia effigia Beveridge, 1976
Aust. J. Zool. Suppl. Ser. **44**: 45-7.

Holotype V773, paratypes V774-5, from *Macropus fuliginosus* (bile duct), Pine Plains Stn., via Patchewollock, Vic., collector I. Beveridge, 28/6/73.

Progamotaenia gynandrolinearis Beveridge & Thompson, 1979
J. Helminthol. **53**: 156-7.

Holotype V1315, paratypes V1316-9, sectioned material V1320, from *Lagorchestes conspicillatus,* Barrow Is., W.A., collector L. Hemsley, 1976.

Progamotaenia johnsoni Beveridge, 1980b
Trans. R. Soc. S. Aust. **104** (4): 69-72.

Holotype V1918 including sections from *Lagorchestes conspicillatus,* paratype V1919, Mingela, Qld., collector I. Beveridge, 10/5/79.

Progamotaenia lagorchestis Beveridge, 1976
Aust. J. Zool. Suppl. Ser. **44**: 55-8.
Now *Progamotaenia thylogale* Beveridge (1976) Beveridge & Thomson, 1979.

Holotype V783, paratypes V784, from *Thylogale billardierii,* Launceston, Tas., collector B. L. Munday.

Progamotaenia macropodis Beveridge, 1976
Aust. J. Zool. Suppl. Ser. **44**: 58-60.

Holotype V776, paratypes V777-8, from *Macropus giganteus,* Yan Yean, Vic., collector J. H. Arundel, 12/9/72.

Progamotaenia ruficola Beveridge, 1978
J. Parasitol. **64** (2): 273-6.

Holotype V1207-10, paratypes V1212-13, AHC 8650, 8651, from *Macropus rufus,* Menindee, N.S.W., collector I. Beveridge, date unknown.

Progamotaenia spearei Beveridge, 1980b
Trans. R. Soc. S. Aust. **104** (4): 67-9.

Holotype V1920, from *Thylogale stigmatica,* Tolga, Qld., collector I. Beveridge, 16/10/78.

Proteocephalus gallardi Johnston, 1911b
Ann. Qld. Mus. **10**: 1-8.

Now *Acanthotaenia gallardi* Johnston (1911) 1912c, Cotypes AHC S80, 81, from *Pseudechis porphyriacus,* Gosford, Richmond, Hunter R. and Sydney, N.S.W., Gippsland, Vic., collectors L. Gallard, C. T. Musson, F. H. Taylor, W. Hall, A. S. Souëff & T. H. Johnston, 1909-1910.

Note: Johnston exhibited some specimens of *A. gallardi* as *Ichthyotaenia* sp. at a meeting of The Royal Society of N.S.W. in 1910. However, a full description of the species was not published (as *P. gallardi*)

until 1911. In his paper Johnston did not designate a type locality, but the slides registered as cotypes with AHC as *Ichthyotaenia gallardi* have Narrara, N.S.W. and Victoria (A. S. Le Souëff collector) as localities. It is known that T. H. Johnston always listed the type locality first.

Raillietina leipoae Johnston & Clark, 1948b
Rec. S. Aust. Mus. **9** (10): 87-90.
Holotype V3044, paratypes AHC 1381, from *Leipoa ocellata,* Tailem Bend, S.A., collector L. Ellis.

Rhinebothrium himanturi Williams, 1964
Parasitology **54**: 740-1.
Holotype V1063, paratype V1064, from *Himantura granulata,* Heron Is. off Rockhampton, Qld., collector J. Pearson, June 1956.

Sphaeruterina punctata Johnston, 1914
Proc. R. Soc. Qld. **26**: 76-80.
Cotypes AHC S369, S79, from *Pachycephala rufiventris,* Caloundra, N.S.W., collector T. H. Johnston, August 1914.

Taenia bairdii Krefft, 1873
Trans. Ent. Soc. N.S.W. **2**: 224-7.
Now *Microsomacanthus collaris* Batsch, 1786, after Yamaguti, 1959, Cotypes AHC S77, from *Anas superciliosa,* N.S.W., collector G. Krefft, date unknown.
Note: The specimens collected by Krefft constituted about half the then known cestodes (Johnston, 1912b). However, his descriptions and figures were not detailed enough for species recognition. Fortunately most of the type material was deposited in The Australian Museum and available for re-examination by Johnston. Although some specimens were poorly preserved Johnston was able to find better preserved material which he identified as the same species as the types in question. Some of Krefft's material as redescribed by Johnston has been deposited in the AHC.

Taenia chlamydoderae Krefft, 1873
Trans. Ent. Soc. N.S.W. **2**: 224.
Now *Paricterotaenia chlamydodere* (Krefft, 1873) Yamaguti, 1959, Cotype AHC S71, from *Chlamydera maculata,* collector G. Krefft, date unknown.

Taenia coronata Krefft, 1873
Trans. Ent. Soc. N.S.W. **2**: 220-1.
Now *Gyrocoelia australiensis* (Krefft, 1873) Johnston, 1921b, Cotypes AHC S72, S344-5, N.S.W., collector G. Krefft, date unknown.

Taenia flacescens Krefft, 1873
Trans. Ent. Soc. N.S.W. **2**: 219.
Now *Diorchis flavescens* (Krefft, 1873) Johnston, 1912b, Cotypes S73-5, S441, from *Anas superciliosa,* N.S.W., collector G. Krefft, date unknown.

Taenia forsteri Krefft, 1873
Trans. Ent. Soc. N.S.W. **2**: 218.
Now *Tetrabothrius forsteri* (Krefft, 1873) Johnston, Cotype AHC 578, 1912b, from *Delphinus forsteri,* Port Jackson, N.S.W., collector and date unknown.

Taenia mastersii Krefft
Trans. Ent. Soc. N.S.W. **2**: 217-8.
Cotype AHC S70, from *Macropus* sp., Qld., collector G. Masters, date unknown.
Note: Beveridge (1976) considered that this species possibly belonged to *Calostaurus.*

Taenia paradoxa Krefft, 1873
Trans. Ent. Soc. N.S.W. **2**: 217-8.
Cotypes AHC S76, S386, from *Podiceps australis,* N.S.W., collector G. Krefft, date unknown.
Note: T. paradoxa is preoccupied by Rudolphi, 1801. Johnston was unable to establish the status of the species which awaits redescription. Krefft named the host Little Grebe, *Podiceps australis.* This is now a synonym of the Crested Grebe. Obviously he meant what is now *Tachybatus novaehollandiae.* The Little Grebe would not be mistaken for the Crested Grebe or vice versa.

Taenia rugosa Krefft, 1873
Trans. Ent. Soc. N.S.W. **2**: 223-4.
Now *Acoelus hedlyi* (Krefft, 1873) Johnston, 1912b, Neotype AHC S339-40, from *Himantopus leucocephalus,* Hunter River, N.S.W., collector G. Krefft, date unknown.
Note: Johnston found the original material so damaged as to be useless, but was able to compare it with fresh material from the same host in South Australia by J. B. Cleland. The armature of the cirrus sac of both lots of material assisted in establishing their identity.

Tholophyllacus johnstoni Mackiewicz & Blair, 1980
Proc. Helm. Soc. Wash. **47** (2): 172-4.
Paratypes V1893-4, from *Tandanus glencoensis,* Ross R. near Townsville, Qld., collectors probably the authors, date unknown.

Triplotaenia fimbriata Beveridge, 1976
Aust. J. Zool. Suppl. Ser. **44**: 69-71.
Holotype V800, paratype V801, from *Macropus giganteus,* Nebo, Qld., collector A. Glassop, 17/8/73.

Triplotaenia undosa Beveridge, 1976
Aust. J. Zool. Suppl. Ser. **44**: 73-5.
Holotype V802, paratype V803, AHC S962, from *Wallabia bicolor,* Dartmouth, Vic., collector I. Beveridge, 22/1/74.

Valipora parvitaeniunca Baer & Bona, 1960
Boll. Inst., Mus. Zool. Torino **6** (4): 9.
Now *Baerbonia p. parvitaeniunca* (Baer & Bona,

1960), 1975, Syntype AHC S308, from *Egretta sacra,* Masthead Is., Qld., collector T. H. Johnston, 1917.

Zosteropicola clelandi Johnston, 1912a
Mem. Qld. Mus. **1**: 214-5.
Cotypes AHC S84, S464, from *Zosterops coecrulescens,* neighbourhood of Sydney, N.S.W., collectors J. B. Cleland, J. O. Heinrich and T. H. Johnson, dates unknown.

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HELMINTH TYPE-SPECIMENS IN THE SOUTH AUSTRALIAN MUSEUM

III. TREMATODA

by

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ABSTRACT

SMALES, L. R., 1983. Helminth type-specimens in the South Australian Museum. III. Trematoda. *Rec. S. Aust. Mus.* **18** (22): 503-511.

Type-specimens of 13 species of Monogenea and 70 species of Digenea are catalogued. All are from Australian or Antarctic hosts. Trematode species are listed alphabetically, according to the original name of the genus, under either Monogenea or Digenea. Where a name change has occurred the most recent name is included. The hosts are given under the name recorded by the author.

INTRODUCTION

This is the third and final paper of a series listing the Helminth Types held by the South Australian Museum and the Australian Helminthological Collection, currently housed in the Museum. There is also a substantial collection of larval material for which the adult has not yet been described. All the specimens described have been collected from Australian or Antarctic hosts.

The species are listed in alphabetical order under the genus to which they were first assigned. Where a name change has occurred the most recent authoritative name is given. Host-species names are those used in the original descriptions.

The earliest material registered is that assembled by T. H. Johnston who was as actively interested in the trematodes as he was in the other helminth groups. The group of parasitologists he established at Adelaide University, including L. M. Angel, now Honorary Associate of the South Australian Museum and still working in the field, provided a significant contribution to knowledge of the Australian trematodes. Other Australian trematologists are now depositing type material at the Museum.

Registration numbers starting with V indicate material held in the South Australian Museum, those starting with AHC, material in the Australian Helminthological Collection. Unless otherwise stated the name Johnston refers to T. H. Johnston. The following abbreviations were used in the text: BANZARE = British, Australia and New Zealand Antarctic Research Expedition, 1929-31; AHC = Australian Helminthological Collection; SAM = South Australian Museum; N.T. = Northern Territory; N.S.W. = New South Wales; Qld. = Queensland; S.A. = South Australia; Tas. = Tasmania; Vic. = Victoria; W.A. = Western Australia.

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CLASS TREMATODA

SUB-CLASS MONOGENEA

Anoplodiscus australis Johnston, 1930
Aust. J. Exp. Biol. Med. Sci. **7**: 108-12.
Holotype V8 from the fin of *Sparus australis*, Sydney Harbour, N.S.W., collector S. J. Johnston, date unknown.
Now *Anoplocotyle australis* (Johnston, 1930) Palombi, 1943.

Calicotyle australis Johnston, 1934
Aust. J. Exp. Biol. Med. Sci. **12**: 25-8.
Holotype V9 probably from the gills of *Trygonorrhina fasciata*, Glenelg, S.A., collector T. H. Johnston, date unknown.

Diplasicotyle johnstoni Sandars, 1944
Trans. R. Soc. S. Aust. **68** (1): 77-81.
Types V850-1 from gills of *Agonostomus forsteri*, Mandurah, Bunbury, W.A., collector probably the author, 1943.
Note: Sandars did not specify a type locality for each species, but some of the type slides have a locality written in her handwriting.

Gonoplasius carangis Sandars, 1944
Trans. R. Soc. S. Aust. **68** (1): 75-7.
Holotype V848 from the gills of *Caranx georgianus*, North Beach, Rockingham, W.A., collector probably the author, 11/6/43.

Microcotyle agonostomi Sandars, 1945
J. R. Soc. W. Aust. **29**: 108-12.
Holotype V846 from the gills of *Agonostomus forsteri*, Swan R., Mandurah, Bunbury, Denmark, Albany, W.A., collector probably the author, 1942.

Microcotyle arripis Sandars, 1945
J. R. Soc. W. Aust. **29**: 114-8.
Holotype V845 from the gills of *Arripis trutta*, North Beach, Swan River, Mandurah, Bunbury, Busselton, Albany, Woodman's Point, Scarborough, Whitfords Beach, W.A., collector probably the author, 18/6/42.

Microcotyle gerres Sandars, 1944
Trans. R. Soc. S. Aust. **68** (1): 67-8.
Holotype V843 from gills of *Gerres ovatus*, Mandurah, W.A., collector probably the author, 14/4/43.

Microcotyle helotes Sandars, 1944
Trans. R. Soc. S. Aust. **68** (1): 72-4.
Cotypes V841 from the gills of *Helotes sexlineatus*, Safety Bay, W.A., collector probably the author, 20/5/43.

Microcotyle odacis Sandars, 1945
J. R. Soc. W. Aust. **29**: 123-6.
Holotype V842 from the gills of *Odax semifasciatus*, Albany, W.A., collector probably the author, April 1941.

Microcotyle parasillaginae Sandars, 1945
J. R. Soc. W. Aust. **29**: 112-4.
Holotype V844 from the gills of *Sillaginodes punctatus*, Albany, W.A., collector probably the author, 14/5/42.

Microcotyle pentapodi Sandars, 1944
Trans. R. Soc. S. Aust. **68** (1): 69-70.
Holotype V839 from the gills of *Pentapodus milii*, Rockingham, W.A., collector probably the author, 26/4/43.

Microcotyle scorpis Sandars, 1944
Trans. R. Soc. S. Aust. **68** (1): 71-2.
Holotype V840 from the gills of *Scorpis aequipinnis*, Safety Bay, W.A., collector probably the author, 14/1/43.

Microcotyle temnodontis Sandars, 1945
J. R. Soc. W. Aust. **29**: 119-23.
Cotypes V847 from the gills of *Temonodon saltator*, Bunbury, W.A., collector probably the author, 2/4/42.

SUB-CLASS DIGENEA

Apatemon (*Apatemon*) *vitelliresiduus* Dubois & Angel, 1972
Trans. R. Soc. Aust. **96** (4): 199-201.
Holotype V1068 from the intestine of *Biziura lobata*, Purnong and Caloot, Murray R., S.A., collector P. M. Mawson, 20/6/58.
Paratypes V1069, three specimens on the same slide as the holotype.

Bancroftrema neocerotodi Angel, 1966
J. Parasitol. **52** (6): 1058-61.
Holotype V955 from the digestive tract of *Neoceratodus forsteri*, Qld., collector T. L. Bancroft, January 1911.
Paratypes V956-8, juveniles, one sectioned.

Brachylecithum dacelonis Angel & Pearson, 1977
Trans. R. Soc. S. Aust. **101** (5): 122.
Holotype V89 from the liver of *Dacelo novaeguineae*, Bridgewater, S.A., collector P. M. Mawson, July 1973.
Paratypes V90, 91; AHC S15.

Brachylecithum hydromyos Angel & Pearson, 1977
Trans. R. Soc. S. Aust. **101** (5): 121.
Holotype V82 from the pancreatic ducts of *Hydromys chrysogaster*, Lily Ck., Cairns, Qld., collector C. M. Weaver, 14/2/75.
Paratypes V83, 84; AHC S14.

Brachylecithum insulare Angel & Pearson, 1977
Trans. R. Soc. S. Aust. **101** (5): 119-21.
Holotype V76 from gall bladder and bile ducts of *Rattus fuscipes*, Pearson Is., S.A., collector P. E. Hornsby, date unknown.
Paratypes V77, 78, 79; AHC S2.

Brachylecithum latius Angel & Pearson, 1977
Trans. R. Soc. S. Aust. **101** (5): 123-4.
Holotype V102 from the gall bladder of *Cracticus torquatus*, Cowell, S.A., collector P. M. Mawson, 27/5/65.
Paratypes V103-5; AHC S24-6.

Brachylecithum podargi Angel & Pearson, 1977
Trans. R. Soc. S. Aust. **101** (5): 212-3.
Holotype V92 from the bile ducts of *Podargus strigoides*, Moggill, Qld., collector J. C. Pearson, 6/11/62.
Paratypes V103-5; AHC S20.

Burnellus trichofurcatus Angel, 1971
Parasitology **62**: 375-84.
Holotype V977 from the intestine of *Tandanus tandanus*, Murray R., S.A., collector T. H. Johnston, L. M. Angel, dates unknown.
Paratypes V978-987, other paratype material in AHC.
Cercariae V930, V2772, Sporocysts V931 as used in the original descriptions of the juvenile stages of the life cycle by Johnston & Angel (1940a).

Cardiocephaloides ovicorpus Dubois & Angel, 1972
Trans. R. Soc. S. Aust. **96** (4): 204.
Holotype V1070 from the intestine of an unknown host, no collection data, from SAM.
Paratypes V1071 including sectioned material.

Catatropis gallinule Johnston, 1928
Rec. S. Aust. Mus. **4** (1): 135-8.
Holotype V5 from the caecum of *Gallinula tenebrosa*, Adelaide, S.A., collector probably T. H. Johnston, 1926.

Cetiotrema crassum Manter, 1970
Trans. R. Soc. S. Aust. **94**: 147-50.

Holotype V1004 from the ureter of *Thunnus thynnus maccoyii*, East Bass Strait and Kangaroo Is., S.A., collected by CSIRO, 1939.

Coelomotrema antichinomes Angel, 1970
Aust. J. Zool. **18**: 119-24.
Holotype V974, from the body cavity of *Antechinomys spenceri*, Sandringham Stn. near Bedourie, Qld., collectors P. Woolley & M. Stanley, caught 18/6/68, died 22/10/68.
Paratypes V975, 976 including sectioned material and AHC.

Cotylurus (*Cotylurus*) *magneacetabulus* Dubois & Angel, 1972
Trans. R. Soc. S. Aust. **96** (4): 204-5.
Holotype V1072 from the lower intestine of *Cygnus atratus*, Tailem Bend, S.A., collector T. H. Johnston, 25/10/45.
Paratypes V1072 (six on same slide as holotype), V1073.

Cyclocoelum jaenschi Johnston & Simpson, 1940a
Trans. R. Soc. S. Aust. **64** (2): 273-8.
Holotype V949 from the abdominal air sacs of *Podiceps novaehollandiae*, Tailem Bend, S.A., collectors G. & F. Jaensch, August 1937.

Cercariaeum jaenschi Cercariae V948 as used in the original descriptions of the juvenile stages of the life cycle.
Note: Although a type-host is not designated in the original description the type-slide has host data in T. H. Johnston's handwriting.

Cylindrotrema cygni Angel, 1973
Int. J. Parasitol. **3**: 853-7.
Holotype V1119 from the caecum of *Cygnus atratus*, Tailem Bend, S.A., collector T. H. Johnston, 20/8/51.

Diplostomum murrayense Johnston & Angel, 1941a
Trans. R. Soc. S. Aust. **65** (1): 140-4.
Holotype V952 from the digestive tract of *Childonias leucopareia*, Tailem Bend, S.A., collector G. & F. Jaensch & L. Ellis, 7/2/40.
Paratypes V944.

Cercaria murrayensis Johnston & Cleland, 1938
Cercariae V941-2, V2768, Diplostomulum V943, as used in the original descriptions of the juvenile stages of the life cycle.

Diplostomum (*Diplostomum*) *parvulum* Dubois & Angel, 1972
Trans. R. Soc. S. Aust. **96** (4): 206-8.
Holotype V1074 from the intestine of *Hydroprogne caspia*, Tailem Bend, S.A., collector T. H. Johnston, December 1939.
Paratypes V1074 (three on same slide as holotype), V1075.

Dolichopera macalpini Nicoll, 1914
Parasitology **6** (4): 333-50.
From *Notechis scutatus* and *Denisonia superba*, collected in N.S.W., S.A., Vic. and Tas., now *Dolichoperoides macalpini* (Nicoll, 1914) Johnston & Angel (1940b).
Cercariae V924-5, metacercariae V926, sporocysts V923, and sections of infected *Ameria pyramidata* V927 as used in the original descriptions of the juvenile stages of the life cycle.

Derogenes johnstoni Prudhoe & Bray, 1973
BANZARE Rep. Ser. B **8** (10): 221-2.
Cotypes V563 from *Artedidraco shackeltoni* (site in host not known), 65°48′S, 53° 16′E, collector T. H. Johnston, 24/1/30.
Note: Prudhoe & Bray (1973) did not specify type host and type locality or designate a holotype for any of the trematodes collected by T. H. Johnston during BANZARE.

Echinochasmus pelecani Johnston & Simpson, 1944b
Trans R. Soc. S. Aust. **68** (1): 113-9.
Syntypes V1059 from the small intestine of *Pelecanus conspicillatus*, Tailem Bend, S.A., collectors G. & B. Jaensch & L. Ellis on several occasions between 1938-44.
Cercariae V939, V2806, cysts and redia V2805, metacercariae V940, infected *Gambusia affinus* V2807 as used in the original description of the juvenile stages of the life cycle.
Note: Johnston & Simpson (1944) considered that a more detailed description of *E. mordax* Looss, 1899 would show that *E. pelecani* was a synonym of that species. However Yamaguti (1971) still lists *E. pelecani* separately with the note that it is probably a synonym of *E. mordax*.

Echinoparyphium ellisi Johnston & Angel, 1949
Rec. S. Aust. Mus. **9** (2): 247-54.
Type adult V902 from the duodenum of *Chenopis atratus*, Tailem Bend, S.A., collectors Messrs Jaensch & Ellis, April 1947.

Cercaria ellisi Johnston & Simpson, 1944a
Cercariae V903, 904, metacercariae V905, redia and cercariae V906 as used in the original descriptions of the juvenile stages of the life cycle.

Echinoparyphium hydromyos Angel, 1967
Parasitology **57**: 19-30.
Holotype V57 from the intestine of *Hydromys chrysogaster*, Tailem Bend, S.A., collector L. M. Angel, December 1959.
Paratypes V58.
Cercariae from *Planorbis isingi* V60, cysts from tadpoles and *Lenameria* sp. V59 as used in the original descriptions of the juvenile stages of the life cycle.

Echinostoma australe Johnston, 1928
Rec. S. Aust. Mus. **4** (1): 138-40.
Holotype V6 from the caecum of *Gallinula tenebrosa*, Adelaide, S.A., probably collected by T. H. Johnston, 1926.

Echinostoma bancrofti Johnston, 1928
Rec. S. Aust. Mus. **4** (1): 140-2.
Holotype V7 from the intestine of *Gallinula tenebrosa*, Burnett R., Eidsvold, Qld., collector T. L. Bancroft, 29/9/19.

Foliotrema jecoris Blair, 1981
Aust. J. Zool. Suppl. Ser. **81**: 31-2.
Holotype V1963 from the gall bladder and bile ducts of *Dugong dugon*, Daru, Gulf of Papua, collectors 'Dugong Project' Wildlife Div. Dept. Lands and Environment, Papua New Guinea, 11/7/78.
Paratypes V1964.

Faredifix clavata Blair, 1981
Aust. J. Zool. Suppl. Ser. **81**: 41-3.
Holotype V1973 from large abscesses in the wall of the ileum of *Dugong dugon*, Mornington Is., Qld., collected by aboriginals for food, 11/11/76.
Paratypes V1974-6 including sectioned material.

Galactosomum angelae Pearson, 1973
Phil. Trans. R. Soc. Lond. B **266** (879): 361.
From the small intestine of *Hydroprogne caspia*, Port R., S.A., collector unknown, September 1928, donated by L. M. Angel.
Paratypes V1029.

Galactosomum bearupi Pearson, 1973
Phil. Trans. R. Soc. Lond. B **266** (879): 368.
From the small intestine of *Hydroprogne caspia*, Townsville, Qld., collector A. J. Bearup, 20/8/68.
Paratypes V1030.

Galactosomum renincola Pearson, 1973
Phil. Trans. R. Soc. Lond. B **266** (879): 409.
From the renal ureter of *Puffinus pacificus*, Heron Is., Qld., collector probably the author, 6/3/68.
Paratypes V1031.

Galactosomum sinuilactis Pearson, 1973
Phil. Trans. R. Soc. Lond. B **266** (879): 415.
From the bursa of *Phalacrocorax varius*, Moreton Bay, Qld., collectors R. Groom & R. Greenhill, 25/7/69.
Paratypes V1032.

Haerator caperatus Blair, 1981
Aust. J. Zool. Suppl. Ser. **81**: 44-7.
Holotype V1977 from the ileum of *Dugong dugon*, Mornington Is., Qld., collected for food by aboriginals, 2/8/78.
Paratypes V1978-1 including sectioned material.

Haplorchis parapumilio Pearson & Ow-Yang, 1982
S-E Asian J. Trop. Med. Pub. Health **13**: 37.
From *Phalacrocorax pygmaeus*, from the small intestine, Pulan Rambut, Jakarta Bay, Java, collector D. Supriadi, 23/6/77.
Paratype V2752.

Haplorchis paravanissimus Pearson & Ow-Yang, 1982
S-E Asian J. Trop. Med: Pub. Health **13**: 50.
From *Nycticorax calendonicus*, from the lower small intestine, Brisbane Botanic Gdns, Qld., collector J. C. Pearson, 8/1/62.
Paratype V2752.

Harveytrema bisculatum Kruse, 1979a
J. Parasitol. **65** (6): 918-20.
Holotype V1677 from the intestine of *Achoerodus gouldi*, Pearson Is., S.A., collector P. M. Mawson, February 1960.
Paratype V1678 (sectioned), AHC S290.

Helicometra scorpaenae Prudhoe & Bray, 1973
BANZARE Rep. Ser. B **8** (10): 213.
Cotypes V458-9, from *Scorpaena cruenta*, 42° 40′S, 148° 27′ 30″E off Maria I., Tas., collector T. H. Johnston, 23/3/31.

Hemistomum intermedium S. J. Johnston, 1904
Proc. Linn. Soc. N.S.W. **1904**: 109-110.
now *Apatemon intermedium* (S. J. Johnston, 1904) T. H. Johnston & Angel, 1951b.
Substitute type V870 from the duodenum of *Chenopis atrata*, Duckmaloi R., N.S.W., collector T. H. Johnston.

Cercaria lessoni V872-3, 875 metacercariae V874, 876, cysts V877 as used in the original description of the juvenile stages of the life cycle by Johnston & Beckwith, 1947a.
Note: The slide deposited in SAM is designated "substitute type" in T. H. Johnston's handwriting and is from material collected at Tailem Bend, S.A. Attempts by Johnston & Angel, 1951b, to trace the original material, were unsuccessful.

Heterophyes bitoquatus Pearson & Pearson, 1983
Sarawak Mus. J. **29**: 171-189.
From *Sterna bergii*, site in host not given, Buntal, Sarawak, collector Guan anak Sureng, 15/12/76.
Paratypes V2607.

Heterophyes chini Pearson & Pearson, 1983
Sarawak Mus. J. **29**: 171-189.
From *Sterna bergii*, site in host not given, Buntal, Sarawak, collector Guan anak Sureng, 15/12/76.
Paratypes V2605-06.

Isoparorchis tandani Johnston, 1927
Trans. R. Soc. S. Aust. **51**: 129-33.
Lectotype V3089 from the gas bladder of *Tandanus tandanus*, Qld., collectors T. L. Bancroft & M. J. Mackerras, date unknown.

Syntypes V3090.
Note: This material was found in T. H. Johnston's slide collection. The labels indicated that it must have been the original material. L. M. Angel designated the slides lectotype and syntypes.

Labicola elongata Blair, 1979
Ann. Parasitol. Hum. Comp. **54** (5): 521-6.
Holotype V1679 from the upper lip of *Dugong dugon*, accidentally drowned in nets used by shark-meshing contractors and given to the dugong research group, James Cook University, Townsville, Qld.
Paratypes V1680-4 including sectioned material.

Lankatrema minutum Blair, 1981
Aust. J. Zool. Suppl. Ser. **81**: 23-4.
Holotype V1954 from cardiac glands of the stomach of *Dugong dugon* collected for food by aboriginals, Mornington Is., Gulf of Carpentaria, 4/8/75.
Paratypes V1946-8 including sectioned material.

Lankatrema microcotyle Blair, 1981
Aust. J. Zool. Suppl. Ser. **81**: 24-7.
Holotype V1949 from the wall of the ileum of *Dugong dugon*, collected for food by aboriginals, Mornington Is., Gulf of Carpentaria, 2/8/78.
Paratypes V1950-3 including sectioned material.

Lankatrema macrocotyle Blair, 1981
Aust. J. Zool. Suppl. Ser. **81**: 27-8.
Holotype V1954 from the wall of the ileum of *Dugong dugon*, collected for food by aboriginals, Mornington Is., Gulf of Carpentaria, 2/8/78.
Paratypes V1955-6 including sectioned material.

Lankatremoides gardneri Blair, 1981
Aust. J. Zool. Suppl. Ser. **81**: 29-31.
Holotype V1957 from pancreatic ducts of *Dugong dugon*, collected for food by Torres Strait Islanders, Thursday Is., Qld., 3/11/76.
Paratypes V1958-62 including sectioned material.

Lecithaster australis Prudhoe & Bray, 1973
BANZARE Rep. Ser. B **8** (10): 218.
Cotypes V503-21, site in host not given, from *Notothenia* spp. and three other hosts, near head of Bras Bossière, Kerguelen and eight other localities, collector T. H. Johnston, 20/21/29.
Syntypes V735.

Lepocreadium angelae Kruse, 1981
Proc. Helm. Soc. Wash. **48**: 195-97.
From *Scorpis georgianus*, Pt Willunga, S.A., collector probably T. H. Johnston, February, 1934.
Paratypes V2753-64.

Leuchochloridium australiense Johnston & Simpson, 1940b
Trans. R. Soc. S. Aust. **64** (1): 119-24.
Holotype V960 from the cloaca of *Pomatostomus superciliosus*, Elwomple, near Tailem Bend, S.A., collector F. Jaensch, August 1938.
Cercariae V959 as used in the original description of the juvenile stages by Johnston & Cleland, 1938.

Lutztrema ailuroedi Angel & Pearson, 1977
Trans. R. Soc. S. Aust. **101** (5): 127-9.
Holotype V108 from bile duct and mouth of gall bladder of *Ailuroedus crassirostris*, Mt Glorious, Qld., collector K. E. Webber, 29/10/62.
Paratypes V109-11; AHC S28.

Macropotrema pertinax Blair, Beveridge & Speare, 1979
Ann. Parasitol. **54** (6): 585-92.
Holotype V1831 (serial sections) from the caecum of *Macropus agilis*, Yabulu, Qld., collector I. Beveridge, 20/8/78.
Paratypes V1832-6 including sectioned material.

Mawsonotrema eudyptulae Angel, 1973
Int. J. Parasitol. **3**: 857-9.
Holotype V1120 from ducts of liver of *Eudyptula minor*, Brighton Beach, S.A., collector, from the Institute of Medical and Veterinary Science, S.A., 11/7/72.
Paratypes V1121 including sectioned material; AHC S33-5.

Mesostephanus neophocae Dubois & Angel, 1976
Bull. Soc. Neuchat. Sci. Nat. **99**: 29-32.
Holotype V75 from intestine of *Neophoca cinerea*, Gulf St Vincent, S.A., collector G. Dubois, 29/1/75.
Paratypes, four specimens on same slide as holotype, AHC S31, S32.

Monostephanostomum manteri Kruse, 1979b
J. Parasitol. **65** (6): 921-3.
Holotype V1911 from intestine of *Arripis georgianus*, Port Willunga, S.A. (February, 1934), Gulf St Vincent, S.A. (April, 1964), collectors T. H. Johnston, and from the Adelaide Fish Market.
Paratype V1912; AHC S306.

Neodiplostomum intermedium Pearson, 1959
Parasitology **49** (1 & 2): 111-9.
From small intestine of *Rattus assimilis*, edge of rain forest, Mt Glorious, Qld., collector probably the author, 1956-7.
Paratypes V836-8.

Neodiplostomum (*Neodiplostomum*) *lanceolatum* Dubois & Angel, 1972
Trans. R. Soc. S. Aust. **96** (4): 209-10.
Holotype V1076 from intestine of *Ninox novaeseelandiae*, Adelaide, S.A., collector P. M. Mawson, April 1959.
Paratypes V1077, four specimens on same slide as holotype.

Neodiplostomum (*Triloborchidiplostomum*) *diaboli* Dubois & Angel, 1972

Trans. R. Soc. S. Aust. **96** (4): 210-2.
Holotype V1078, site in host unknown, from *Sarcophilus harrisii*, Tas., collector B. Munday, October 1969.

Neolepidapedon antarcticus Prudhoe & Bray, 1973
BANZARE Rep. Ser. B **8** (10): 204-5.
Cotypes V406-9 from pyloric caeca of *Coryphaenoides whitsoni*, 66° 21′S, 58° 50′E., collector T. H. Johnston, 7/1/30.

Neolepidapedon dubius Prudhoe & Bray, 1973
BANZARE Rep. Ser. B **8** (10): 205-6.
Cotypes V410-12, V732 from pyloric caeca of *Coryphaenoides whitsoni*, 66° 21′S, 58° 50′E, collector T. H. Johnston, 7/1/30.

Neolepidapedon helicoleni Prudhoe & Bray, 1973
BANZARE Rep. Ser. B **8** (10): 208.
Cotypes V418-24, site in host unknown, from *Helicolenus percoides* and *Scorpaena cruenta*, 42° 40′S, 148° 27′ 30″E, off Maria Is., Tas., collector T. H. Johnston, 23/3/31.

Neolepidapedon trematoni Prudhoe & Bray, 1973
BANZARE Rep. Ser. B **8** (101): 206.
Cotypes V413-7, site in host unknown, collected during AAE 1911, hosts and localities *Trematomus hansonii* 65° 42′S, 92° 10′E. *Trematomus scotti* 65° 20′S, 95° 27′E. *Austrolycichthys brachycephalus* 65° 6′S, 95° 27′E.

Opisthotrema australe Blair, 1981
Aust. J. Zool. Suppl. Ser. **81**: 9-10.
Holotype V1934 from eustachian tubes and middle ear of *Dugong dugon*, collected for food by Torres Strait Islanders, Thursday Is., Qld., 3/11/76.
Paratypes V1735-9 including sectioned material.

Opecoelus scorpaenidicola Prudhoe & Bray, 1973
BANZARE Rep. Ser. B. **8** (10): 209-10.
Cotypes V433-49, site in host unknown, from *Helicolenus percoides*, *Scorpaena cruenta*, and *Lepidoperca tasmanica*, 42° 40′S, 148° 27′ 30″E, off Maria Is., Tas., collector T. H. Johnston, 23/3/31.

Pancreatrema meliphagae Angel & Pearson, 1977
Trans. R. Soc. S. Aust. **101** (5): 129-30.
Holotype V112 probably from bile duct of *Meliphaga ornata*, Blanchetown, S.A., collector P. M. Mawson, April 1965.

Paraneocreadium australiense Kruse, 1978
J. Parasitol. **64** (3): 398-400.
Holotype V1496 from intestine of *Psilocranium nigricans*, Aldinga Reef, S.A., collector P. M. Mawson, 1962.
Paratypes V1497-1501 including sectioned material.

Parorchis acanthus var. *australis* Angel, 1954
Trans. R. Soc. S. Aust. **77**: 164-73.
Holotype V988 from intestine of *Larus novaehollandiae*, Glenelg, S.A., collector T. H. Johnston, 1939.
Paratypes AHC S189.
Cercariae V991-2, metacercariae V994, redia V900, cysts V993, and immature adult V898 as used for the original description of the life cycle.

Pharyngostomoides dasyuri Dubois & Angel, 1972
Trans. R. Soc. S. Aust. **96** (4): 213-4.
Holotype V1079 from small intestine of *Dasyurus viverrinus*, Icena Estate, Tas., from the collection of J. C. Pearson, 9/11/66.
Paratypes V1080.

Petasiger australis Johnston & Angel, 1941b
Trans. R. Soc. S. Aust. **65** (2): 285-91.
Holotype V917, site probably intestine of *Podiceps poliocephalus*, Tailem Bend, S.A., collectors G. & F. Jaensch & L. Ellis, May 1941.

Cercaria gigantura V918-20, V2970, cysts V921 and metacercariae V922 as used for the original description of the life cycle by Johnston & Angel.
Note: a type host was not designated in the original description but on the slide deposited in SAM *Podiceps poliocephalus* is written as the host in T. H. Johnston's own handwriting.

Plagiorchis jaenschi Johnston & Angel, 1951a
Trans. R. Soc. S. Aust. **74** (1): 49-58.
Holotype V858 from small intestine of *Hydromys chrysogaster*, Tailem Bend, S.A., collectors G. G. and Bryce Jaensch between May 1938 and December 1949.
Cercariae V859-60, V3794, sporocysts V861, cysts V2795, V863, metacercariae V862. Infected *Limnaea lessoni* V2796, as used in the original descriptions of the life cycle.

Postmonorchis variabilis Prudhoe & Bray, 1973
BANZARE Rep. Ser. B **8** (10): 202-3.
Cotypes V387-99, site in host unknown, from *Notothenia cyanobrancha*, Port Jeanne d'Arc, Kerguelen, 10/2/30 and Green Harbour, Kerguelen; *Notothenia acuta*, near head of Bras Bossière, Kerguelen, 20/11/29; *Notothenia rossi* 49° 28′S, 70° 33′E off entrance to Royal Sound, Kerguelen, 21/3/30; *Harpagifer bispinus*, Port Jeanne d'Arc, 16/2/30, collector T. H. Johnston.

Probolitrema clelandi Johnston, 1934
Aust. J. Exp. Biol. Med. Sci. **12**: 29-31.
Holotype V12 from body cavity of *Mustelus antarcticus*, Encounter Bay, S.A., collector J. B. Cleland, January, 1922.

Probolitrema rotundatum Johnston, 1934
Aust. J. Exp. Biol. Med. Sci. **12**: 28-9.

Holotype V10 from abdominal cavity of *Trygonorrhina fasciata*, Kangaroo Is., S.A., collector C. J. Hackett, 1933.

Probolitrema simile Johnston, 1934
Aust. J. Exp. Biol. Med. Sci. **12**: 31-2.
Holotype V11 from body cavity of *Mustelus antarcticus*, Encounter Bay, S.A., collector J. B. Cleland, January 1922.

Prototransversotrema steeri Angel, 1969
Parasitology **59**: 719-24.
Holotype V970, under scales of *Aldrichetta forsteri*, North Arm, Port R., S.A., collector B. Steer, July 1968.
Paratypes V971-3.

Pseudopecoelus pyriformis Prudhoe & Bray, 1973
BANZARE Rep. Ser. B **8** (10): 210-2.
Cotypes V450-3, site in host unknown, from *Callanthias allporti*, 42° 40′S, 148° 27′ 30″E, off Maria Is., Tas., collector T .H. Johnston, 23/3/31.

Prosthogonimus vitellatus Nicoll, 1914
Int. J. Parasitol. **3** p. 859—redescription by Angel, 1973.
Type host *Chibia braceteata*. Since the holotype, located at the School of Public Health and Tropical Medicine Sydney, was found to be imperfect six specimens V1122 from *Gymnorhina tibicen leuconata*, Tailem Bend, S.A., have been deposited in SAM, collector T. H. Johnston, 1/6/40.

Skrjabinosomum mawsoni Angel & Pearson, 1977
Trans. R. Soc. S. Aust. **101** (5): 124-6.
Holotype (lateral mount) V96 from liver of *Manorina flavigula*, Port Augusta, S.A., collector SAM, May 1965.
Paratypes V96 (dorsal mount) on same slide as holotype and V97; AHC S18.

Skrjabinosomum pomatostomi Angel & Pearson, 1977
Trans. R. Soc. S. Aust. **101** (5): 126-7.
Holotype V99 from liver of *Pomatostomus superciliosus*, The Bunkers, Flinders Ranges, S.A., collector SAM, 22/7/65.
Paratypes V99, six specimens on same slide as holotype and V100, V101.

Stictodora diplacantha Johnston, 1942
Trans. R. Soc. S. Aust. **66** (2): 239-40.
Holotype V852, site in host not given, from *Phalacrocorax varius*, Port Gawler, S.A., collector probably T. H. Johnston, date unknown.

Stenakron kerguelense Prudhoe & Bray, 1973
BANZARE Rep. Ser. B **8** (10): 214-6.
Cotypes V465-83, V733, site in host not given, from *Notothenia coriiceps* Heard Is., 28/9/29; *Notothenia cyanobrancha* from various stations at Kerguelen between 16/11/29 and 15/2/30; *Champsocephalus gunnari* 49° 28′S, 70° 33′E off entrance to Royal Sound, Kerguelen, 2/3/30; *Zanchlorhynchus spinifer* 54° 42′ 30″S, 158° 54′ 30″E, off Lustitania Bay, Macquarie Is., collector T. H. Johnston, 4/12/30.

Tandanicola bancrofti T. H. Johnston, 1927
Trans. R. Soc. S. Aust. **51**: 133-6.
Cotypes V3088, from the gas bladder of *Tandanus tandanus*, Burnett R., Eidsvold, Qld., collectors T. L. Bancroft and M. J. Mackerras, date unknown.

CERCARIA

Cercaria acetabulopapillosa Angel & Manter, 1972
Ann. Inst. Biol. Univ. Nal. Auton Mexico **41** Ser. Zool. 1: 5-9.
Cercariae and metacercariae, V1007-12; redia V1008, redia and cercariae V1013; infected *Plotopsis tetrica* with redia and cercariae V1014; cysts V1015.

Cercaria amerianne Johnston & Beckwith, 1947a
Rec. S. Aust. Mus. **8** (4): 575-782.
Cercaria, V880, V2799; diplostomula and sporocysts V881, V882, V2880, infected *Limnodynastes* sp. V2801.

Cercaria ancyli Johnston & Beckwith, 1947b
Trans. R. Soc. S. Aust. **71** (2): 324-8.
Cercaria 2788, V884, sporocysts V883; infected *Ameria pyramidata* V2787.

Cercaria angelae Johnston & Simpson, 1944a
Trans. R. Soc. S. Aust. **68** (1): 130-2.
Cercariae V888, V2789; sporocyst V887; tetracotyle V889-91: from *Amerianna pyramidata* and *A. tenuirostra.*

Cercaria beckwithae Johnston & Angel, 1949b
Trans. R. Soc. S. Aust. **73** (1): 22-7.
Cercariae V2778, V895, V896; infected *Planorbis isingi* V2779-80.

Cercaria clelandi Johnston & Angel, 1939
Trans. R. Soc. S. Aust. **63** (2): 200-3.
Cercaria V950, V2766; redia V951: from *Planorbis isingi.*

Cercaria gigantura var. *grandior* Johnston & Simpson, 1944a
Trans. R. Soc. S. Aust. **68** (1): 128-30.
Cercaria V893, V2790; redia V892-3; metacercaria V894; infected *Amerianna pyramidata* V2792.

Cercaria haswelli Dolfuss, 1927
Sobrito del libro Homenaje al Dr Edwardo Caballero y Caballero Mex. 1960: 75-85.
Haswell's 1903 material, redescribed Angel, 1960. Cercariae and sporocysts V1054.

Cercaria jaenschi Johnston & Cleland, 1937
Trans. R. Soc. S. Aust. **61**: 202-6.
Cercariae V1057; infected *Lenameira* sp. V1055; infected *Amira pyramidata* serial sections, V1058.

Cercaria lethargica Johnston & Muirhead, 1949
Trans. R. Soc. S. Aust. **73** (1): 106-8.
Cercariae V868, V2783; metacercariae V869; sporocysts V867; cysts V2784: from *Plotopsis tatei.*

Cercaria lophosoma Johnston & Beckwith, 1947b
Trans. R. Soc. S. Aust **71** (2): 328-333.
Cercaria V886, V2785; sporocysts V885; infected *Notopala hanleyi* V2786.

Cercaria metadina Johnston & Angel, 1942
Trans. R. Soc. S. Aust. **66** (1): 50-9.
Cercaria V908-9, V2769; sporocysts V907; sporocysts with diplostomula V910-3; diplostomula V914-6: from *Planorbis isingi, Amerianna pyramidata* and *A. tenuirostra.*

Cercaria natans Johnston & Muirhead, 1949
Trans. R. Soc. S. Aust. **73** (1): 102-6.
Cercariae, V865, V2781; metacercariae V866; redia V864; infected *Planorbis isingi* V2782.

Cercaria notopalae Johnston & Beckwith, 1945
Trans. R. Soc. S. Aust. **69** (2): 234-41.
Cercaria (furcocercaria) V879, V2775; sporocysts V878; infected *Notopala hanleyi* V2776.

Cercaria parocellata Johnston & Simpson, 1939
Trans. R. Soc. S. Aust. **63** (1): 63-5.
Cercariae V945-6, V2773: from *Lymmaea lessoni.*

Cercaria plotiopsis Johnston & Simpson, 1939
Trans. R. Soc. S. Aust. **63** (1): 65-8.
Cercariae V947, V2774: from *Plotopsis tatei.*

Cercaria tatei Johnston & Angel, 1940a
Trans. R. Soc. S. Aust. **64** (2): 334-9.
Cercariae V932-4, V2771; metacercariae V938; sporocysts and cysts V935-7: from *Plotopsis tatei.*

Cercaria tetradena Johnston & Beckwith, 1945
Trans. R. Soc. S. Aust. **69** (2): 229-33.
now *Cercaria tetradenoidea* (Johnston & Beckwith, 1945) Johnston & Angel, 1940b.
Cercaria (furcocercaria) V928, V2777; sporocysts V929: from *Plotopsis tatei.*

Cercaria velesunionsis Angel, 1961
Trans. R. Soc. S. Aust. **84**: 63-70.
Cercariae V998-99, V1003; metacercariae V995-7, V1002, young adults V1000-1: from *Velesunio ambiguis.*

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A REVISION OF THE GENUS *APLEROTUS* DALLAS (HETEROPTERA: PENTATOMIDAE: PENTATOMINAE) WITH DESCRIPTION OF A NEW SPECIES FROM SOUTH AUSTRALIA[1]

by

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ABSTRACT

AHMAD, I., KHAN, N. A., and KAMALUDDIN, S. 1982. A revision of the genus *Aplerotus* Dallas (Heteroptera:Pentatomidae:Pentatominae) with description of a new species from South Australia. *Rec. S. Aust. Mus.* **18** (23): 513-518.

A new species *grossi* of the genus *Aplerotus* Dallas, 1851 is described from South Australia, with special reference to its metathoracic scent gland ostioles and male and female genitalia. The type species, *A. maculatus* Dallas, is redescribed. The relationships of the genus within the subfamily Pentatominae are also briefly discussed.

INTRODUCTION

Aplerotus Dallas is to date monotypic and appears quite common all over eastern, western and southern Australia (Gross, 1976). The type species *A. maculatus* Dallas is known only by a short original description of Dallas (1851) mostly based on colour features and a more detailed description of Gross (op. cit.) including, in addition to external features, in the male genitalia the structures of parameres, pygophore and uninflated aedeagus. Gross (op. cit.) noted that seven attempts, all unsuccessful, were made to inflate the aedeagus. The female genitalia of the type species are entirely unknown.

By the courtesy of Dr G. F. Gross, Principal Curator of the South Australian Museum, Adelaide, Australia, the present authors were able to examine a long series of specimens from various localities from eastern, southern and western Australia which clearly represented a complex of two species on the basis of consistent differences in the characters of general size, colour patterns on the central disc of scutellum (Figs. 1 & 11), shapes of peritremes of the metathoracic scent gland ostioles (Figs. 2 & 12) and structure of the male and female genitalia (Figs. 3-9 & 13-19) as noted in the present descriptions and "comparative notes" under each species. The holotype of *A. maculatus* Dallas (without abdomen) was examined by the senior author by the courtesy of Drs P. Freeman, Keeper of Entomology, and W. J. Knight, who is in charge of the Hemiptera section, the British Museum of Natural History, London during his visit to that museum in the year 1977-78.

The new species is named *grossi* in honour of Dr G. F. Gross in recognition of his voluminous taxonomical works on various groups of pentatomomorphous Heteroptera. For measurements and diagrams and for dissection of male and female genitalia, the conventional procedures especially those of Ahmad and Khan (1980) have generally been followed.

Genus *APLEROTUS* Dallas

Aplerotus Dallas, 1851, p. 256; Gross, 1976, p. 370.

Description: Coloration: Generally dark but brilliantly patterned; pronotum with a pale median streak and corium near apex with a broad transverse pale stripe.

Head: Eyes only slightly stalked; paraclypei more or less equal to clypeus; antennae four-segmented with basal segments at least reaching or distinctly passing beyond head apex; antenniferous tubercles spinously produced; labium short, never passing beyond hind coxae, with basal segment slightly passing beyond bucculae.

Thorax: Pronotum more than 2½x broader than long, lateral margins entire; metathoracic scent gland ostiole with peritreme elongated, blade-like, evaporative area well defined.

Abdomen: Convex beneath without sulcation, stridulatory vittae present forming a curved line laterally on 2nd, 3rd and 4th abdominal segments.

Male genitalia: Pygophore broader than long, dorsomedian surface posteriorly produced into a rounded or blunt process, lateral lobes prominent and broad; parameres elongate with outer margin medially straight, anteriorly prominently inwardly curved and more or less blade-like with serrated margins; inflated aedeagus with trilobed dorsal membranous conjunctival appendage, vesica long but shorter than distantly placed and proximally attached median penial plates, sclerotized conjunctival appendages and membranous lobes present.

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Female genitalia: First gonocoxae widely separated; 9th paratergites lobe-like, passing beyond posterior margin of 8th paratergites; triangulin, arcus and 2nd gonocoxae quite prominent and sclerotized; spermathecal bulb without processes, proximal and distal flanges well developed, proximal spermathecal duct longer than distal one.

Comparative note: Aplerotus Dallas appears most closely related to *Diemenia* Spinola and *Niarius* Stål among the *Diemenia* group in having four-segmented antennae. It resembles *Diemenia* and *Kalkadoona* Distant in having median penial plates and the latter in having sclerotized second paired conjunctival appendages and other membranous and sclerotized conjunctival appendages in the aedeagus but can be separated from both in having the lateral margins of the head in front of the eyes without even a reduced tooth, the pronotal lateral margins entire, without trace of crenulations and the parameres unique among the entire subfamily Pentatominae.

Aplerotus maculatus Dallas

(Figs. 1-10)

Aplerotus maculatus Dallas, 1851, p. 256; Gross, 1976, p. 372.

Description: Coloration: Body black, uniformly punctate except for a faint vertical line on middle of clypeus, anterolateral margins of pronotum on each side and a vertical median line of pronotum; a small rounded patch on each basal angle, a median patch on mediolateral margins and a single apical patch on scutellum; a horizontal broad streak on each corium and proximal portion of each connexival joint pale; eyes brownish black, ocelli light pinkish.

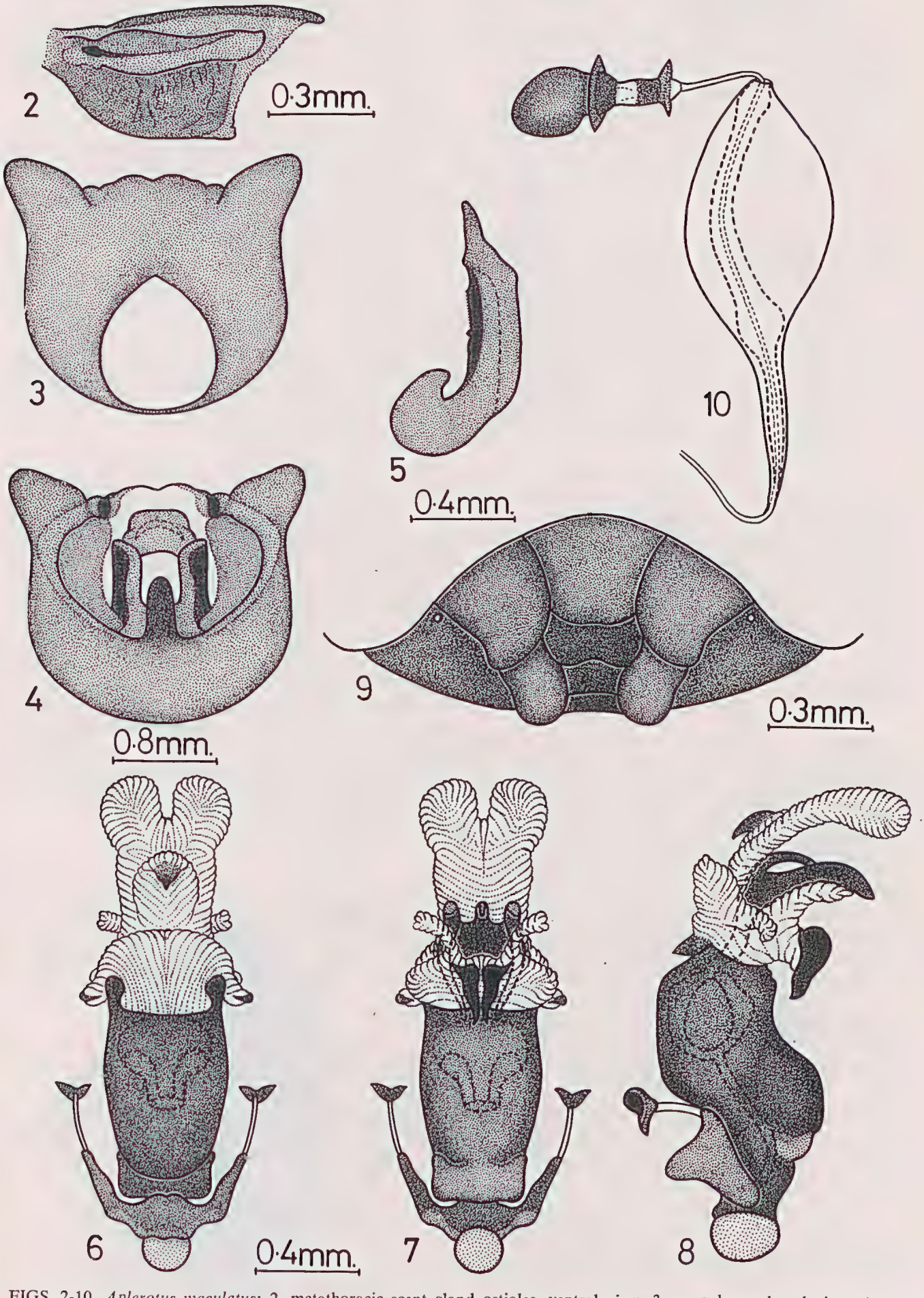
FIG. 1. *Aplerotus maculatus.*

Head: Anteocular portion shorter than the posterior portion of head including eyes, length of anteocular portion 0.7 mm (0.7-0.8 mm); length posterior portion of head including eyes 0.9 mm (0.8-1.05 mm); width of head 2.3 mm (2.21-2.8 mm); interocular distance 1.2 mm (1.1-1.4 mm); interocellar distance 0.7 mm (0.7-0.8 mm); paraclypei with anterolateral margin nearly straight, anteriorly narrowed; antennae with basal segment almost equal to apex of head, 3rd segment distinctly longer than 4th, length of segments 1 0.6 mm, 2 1.8 mm (1.8-2.1 mm), 3 1.3 mm (1.3-1.5 mm), 4 1.2 mm (1.2-1.35 mm); antennal formula 1<4<3<2; labium short, not quite reaching hind coxae, 4th segment distinctly longer than basal segment, length of segments, 1 0.6 mm (0.6-0.7 mm), 2 1.0 mm (0.9-1.0 mm), 3 0.8 mm (0.8-0.9 mm), 4 0.7 mm (0.7-0.8 mm), labial formula 1<4<3<2.

Thorax and Abdomen: Pronotum slightly longer than head; length 1.7 mm (1.6-2.0 mm); width 4.45 mm (4.2-5.2 mm). Scutellum slightly longer than 2x head length; length 3.3 mm (3.25-3.8 mm); width 2.9 mm (2.7-3.3 mm); metathoracic scent gland ostioles (Fig. 2) with apex of peritreme curved anteriad; length base scutellum-apex clavus 1.3 mm (1.2-1.4 mm); apex clavus-apex corium 1.1 mm (1.0-1.1 mm); apex scutellum-apex abdomen including membrane 3.3 mm (3.1-3.5 mm); posterior margin of 7th abdominal segment in females shallowly concave, inner lateral margin convex; total length ♂ 9.9 mm (9.3-9.9 mm), ♀ 10.6 mm (10.85-11.2 mm).

Male genitalia: Pygophore (Figs. 3 & 4) with posteroventral margin medially notched, apex of dorso-median process rounded, inner dorsal process large, straight, with outer margin entire; parameres (Fig. 5) broad, with fine serration on middle of inner margin and a large tooth-adjacent to it near proximal end; theca (Figs. 6-8) with broad, knob-like dorsolateral appendages, median lobe of dorsal membranous conjunctival appendage short with apex sclerotized, with lateral margin sinuate, a pair of lobe-like dorsolateral membranous conjunctival appendages present with apex sclerotized, frontal or 2nd pair of conjunctival appendages with apex broad, proximolaterally broad, median penial plates anteriorly pointed, posteriorly elongated with apex acute.

Female genitalia: (Figs. 9 & 10). Lateral margins of 1st gonocoxae concave; 9th paratergites with lateral margins concave; triangulin and arcus fused



FIGS. 2-10. *Aplerotus maculatus*: 2, metathoracic scent gland ostioles, ventral view; 3, pygophore, dorsal view; 4, pygophore, ventral view; 5, paramere, inner view; 6, aedeagus, dorsal view; 7, aedeagus, ventral view; 8, aedeagus, lateral view; 9, female genitalia, ventral view; 10, spermatheca.

with posterior margin, medially indistinctly impressed; 2nd gonocoxae with posterior margin medially impressed; proctiger with posterior margin nearly straight, posteriomedian margin fused; 8th paratergites slightly concave; spermatheca (Fig. 10) with pump region narrowed, tube-like, distally broad, median sclerotized duct of spermathecal dilation distally and medially much dilated, proximal spermathecal duct slightly longer than distal spermathecal duct.

Material examined: Holotype ♀ Australia; *Aplerotus maculatus* Dallas; in British Museum Natural History, London. 9 ♂, 6 ♀ South Australia: Aroona Dam, Eringunda Valley; Western Australia: E. Balladonia; on *Exocarpos cupressiformis* Labill, at light and on *Exocarpos aphyllus* R. Br., 19.9.1963, 19.3.1967, 1.12.1968, 6.3.1973, 17-24.11.1975; G. F. Gross, E. G. Matthews and N. McFarland; South Australian Museum, Adelaide, Australia.

Comparative note: A. maculatus is closely related to *A. grossi*, but it can easily be separated by its short labium not reaching the hind coxae, in males parameres with a large tooth at medioinner margins and in females, the pump region of the spermatheca large, tube-like, equal to the length of the spermathecal bulb and by other characters as noted in the description.

Aplerotus grossi sp. nov.

(Figs. 11-20)

Description: Coloration: Body black, uniformly punctate except for a prominent vertical line on middle of clypeus; anterior thin and lateral wide portion, a pair of small posterior spots and a wide vertical median band of pronotum; a small rounded patch on each basal angle, a broad inverted T-shaped band on middle and a single apical patch on scutellum; thin posterolateral portion of embolium; anterior horizontal broad band on each corium and proximal portion of each connexival joint dull pale; eyes brownish black; ocelli light pinkish.

Head: Anteocular distance distinctly shorter than posterior portion of head including eyes; length of anteocular portion 0.65 mm (0.65-0.7 mm); length posterior portion of head including eyes 0.85 mm (0.8-1.0 mm); width of head 2.1 mm (2.05-2.3 mm); interocular distance 1.15 mm (1.1-1.25 mm); interocellar distance 0.7 mm (0.7-0.8 mm); paraclypei with anterolateral margin prominently convex, anteriorly broad, antennae with basal segments noticeably passing apex of head; 3rd segment about equal to or slightly longer than 4th segment, length of segments 1 0.55 mm (0.5-0.55 mm), 2 1.70 mm (1.65-1.9 mm), 3 1.15 mm (1.1-1.3 mm), 4 1.15 mm (1.1-1.125 mm); antennal formula 1<3 = 4<2; labium reaching distinctly beyond hind coxae, 4th segment equal in length to basal segment, length of segments 1 0.6 mm, 2 0.9 mm (0.9-1.0 mm), 3 0.8 mm (0.8-0.9 mm), 4 0.6 mm, labial formula 1<4<3<2.

Thorax and Abdomen: Pronotum slightly shorter than head, length 1.45 mm (1.35-1.7 mm); width 3.9 mm (3.7-4.5 mm); scutellum slightly shorter than 2x head length; length 2.8 mm (2.7-3.3 mm); width 2.4 mm (2.3-3.0 mm); metathoracic scent gland ostioles (Fig. 12) width apex of peritremes narrowed and directed laterad; length base scutellum-apex clavus 1.3 mm (1.1-1.5 mm); apex clavus-apex corium 1.0 mm (1.0-1.2 mm); apex scutellum-apex abdomen including membrane 3.1 mm (2.9-3.2 mm); posterior margin of 7th abdominal sternum in females deeply concave, inner margins straight, total length ♂ 8.85 mm (8.4-8.85 mm); ♀ 9.85 mm (9.6-9.9 mm).

Male genitalia: Pygophore (Figs. 13 & 14) with posteroventral margin medially impressed into a pit, apex of dorsomedian process truncated, inner dorsal process large, curved with outer margin sinuate; parameres (Fig. 15) narrowed, small dentation at inner margin near apex; prominent theca (Figs. 16-18) with comparatively narrowed knob-like dorsolateral appendages, median lobe of dorsal membranous conjunctival appendage short with apex sclerotized, lateral margins concave, a pair of lobe-like dorsolateral membranous conjunctival appendage with apex sclerotized, frontal or 2nd pair of conjunctival appendages sclerotized with apex narrowed, proximolaterally narrowed median penial plates anteriorly rounded, posteriorly elongated with apex blunt and rounded.

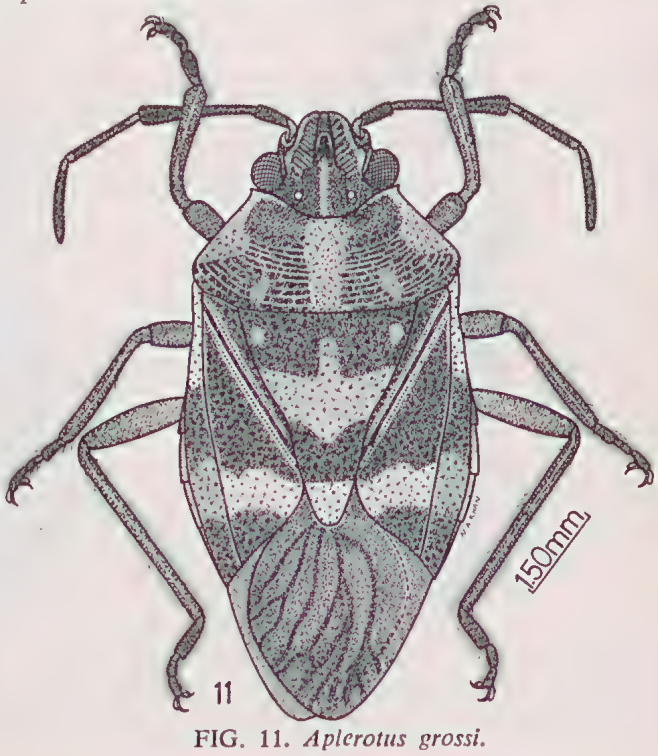
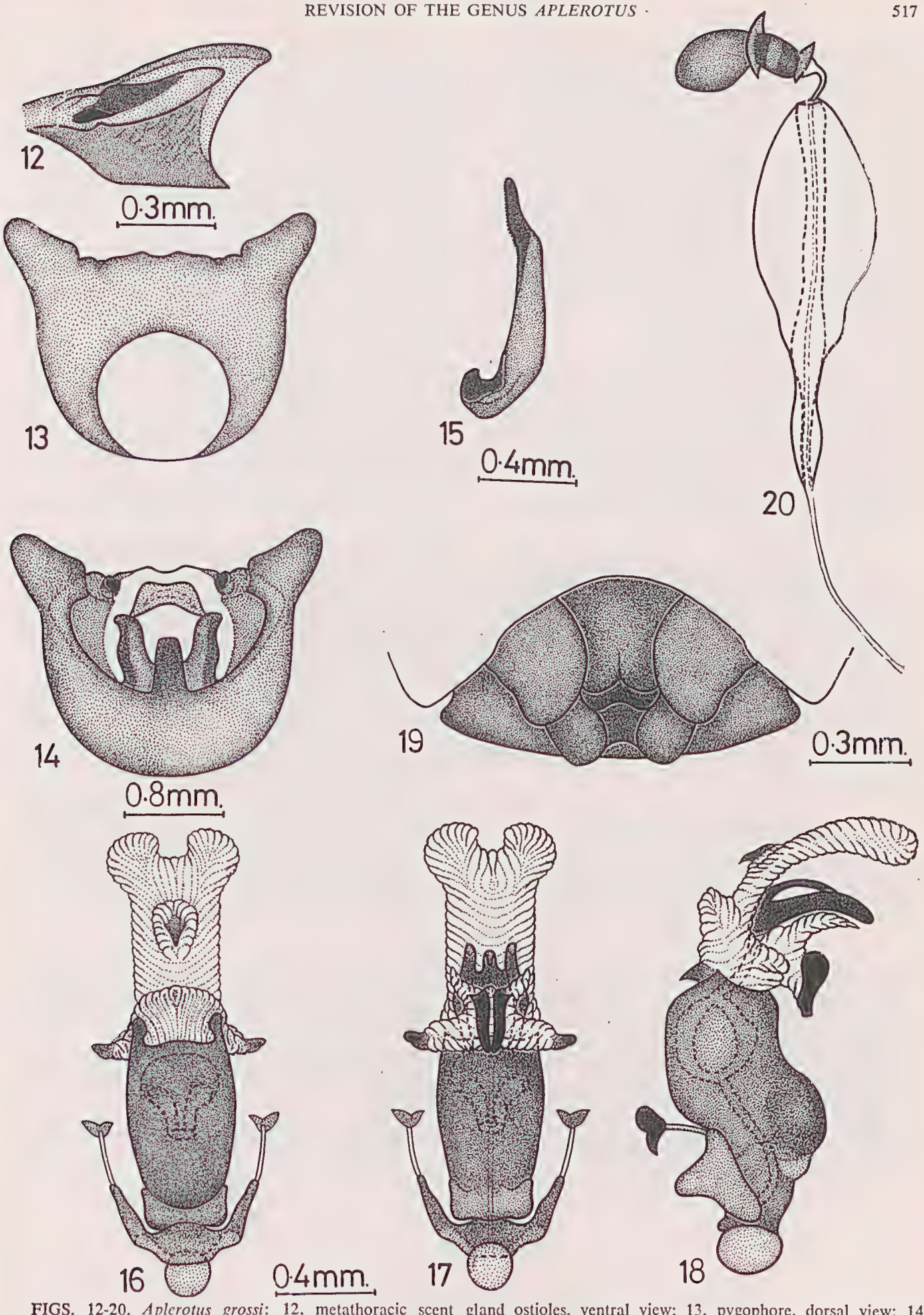


FIG. 11. *Aplerotus grossi.*



FIGS. 12-20. *Aplerotus grossi*: 12, metathoracic scent gland ostioles, ventral view; 13, pygophore, dorsal view; 14, pygophore, ventral view; 15, paramere, inner view; 16, aedeagus, dorsal view; 17, aedeagus, ventral view; 18, aedeagus, lateral view; 19, female genitalia, ventral view; 20, spermatheca.

Female genitalia: (Figs. 19 & 20). Lateral margins of 1st gonocoxae sinuate; 9th paratergites with lateral margins convex; triangulin and arcus fused with posterior margin medially distinctly notched; 2nd gonocoxae with posterior margin medially concave; proctiger with posterior margin deeply concave; posteriomedian margin of fused 8th paratergites slightly convex; spermatheca (Fig. 20) with pump region broad, barrel-shaped, shorter than spermathecal bulb, median sclerotized duct of spermathecal dilation much dilated near proximal end, proximal spermathecal duct more than 4x as long as distal spermathecal duct.

Material examined: Holotype ♂ South Australia: Sceale Bay, 16.10.1963: G. F. Gross; paratypes: 4 ♂ and 3 ♀ South Australia; Sceale Bay, Eringunda Valley; 16.10.1963, 11.11.1966, 6.3.1973, 4.12. 1974, 24.11.1975; at light; G. F. Gross, E. G. Matthews; all in the South Australian Museum, Adelaide, South Australia.

Comparative note: A. grossi is closely related to *A. maculatus* Dallas, but it can readily be separated by having the anterolateral margins of the paraclypei strongly convex, the metathoracic scent gland ostioles with peritremes sinuate, blade-like, apex subacute, in males, the parameres with dentation on the inner apical margin and in female spermatheca with the pump region short, barrel-shaped, shorter than the bulb and by other characters as noted in the description.

SYSTEMATIC POSITIONS

The members of the genus *Aplerotus*, by virtue of the possession of strigose vittae, have variously been placed in the tribes Mecideini Distant and Diemenini Kirkaldy and the *Diemenia* group of Gross (1976). Gross included nine genera occurring in South Australia. The three genera mentioned here were keyed out together as all having four-segmented antennae. Gross (op. cit.) described and figured the aedeagus and parameres of representatives of *Diemenia*, *Kalkadoona* Distant and *Oncocoris* Mayr, and the spermatheca of *O. desertus* Bergroth. McDonald and Edwards (1978) and McDonald (1978, 1979) described and figured the male and female genitalia of all species of *Oncocoris* and of one species of *Kalkadoona*. The male and female genitalia of other members of the group are virtually entirely unknown. Ahmad and Khan (1980) described *Knightiella* to accommodate *Stenozygum flavifrons* Distant, which also possesses strigose vittae. Probably the strigose vittae are shared by the members of remarkably diverse groups in the same way as pseudoclaspers are known in three very diverse genera of pentatomids (McDonald 1976).

On the basis of the male genitalia of the known members of the *Diemenia* group the two species of *Aplerotus* certainly share the characters of medial penial plates, sclerotized paired second conjunctival appendages (presently called frontal appendages) and various membranous lobes and sclerotized appendages of the conjunctiva, which are especially similar to those of *Kalkadoona pallida* (Van Duzee). The structure of the parameres, pygophore and other details of the inflated aedeagus of *Aplerotus* appear, however, to be entirely different and isolate it from the rest of its group like *Knightiella* which also appears to be very different from other Pentatominae (Ahmad and Khan 1980). The male genitalia of *Niarius* are unknown. It could be that this genus and *Aplerotus* would form a group.

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